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TO:	Erin Thomson U.S. Patent and Trademark Office
FROM:	Scott D. Malpede
RE:	U.S. Patent Appln. No. 10/552,590 Docket No.: 00684.103077A
FAX NO.:	(571) 273-0459
DATE:	April 17, 2006 — **NO. OF PAGES:** *(including cover page)* 6
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00684.103077A

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	:	Examiner: Unassigned
NORIYUKI SHIKINA, ET AL.	)	
	:	Group Art Unit: Unassigned
Application No.: 10/552,590	)	
	:	
Filed: October 12, 2005	)	
	:	
For: ELECTROPHORETIC DISPERSION LIQUID AND ELECTROPHORETIC DISPLAY DEVICE	) :)	April 17, 2006

VIA FACSIMILE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450
Attn.: Erin Thomson

FACSIMILE TRANSMISSION OF PREVIOUSLY-FILED PAPER

Sir:

Attached is a true and correct copy of a Request to Consolidate Applications and Request to Withdraw Previously-Filed Petition for Express Abandonment, which was filed on March 24, 2006. A copy of the date-stamped postcard is also attached.

Appln. No.: 10/552,590

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,

Scott D. Malpede
Attorney for Applicants
Registration No. 32,533

FITZPATRICK, CELLA, HARPER & SCINTO
30 Rockefeller Plaza
New York, New York 10112-3801
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I hereby certify that this correspondence is being facsimile transmitted to the Patent and Trademark Office (Fax No. (571) 273-0459 on

April 17, 2006
(Date of Deposit)

Scott D. Malpede
(Name of Attorney for Applicant)

Signature | April 17, 2006
Date of Signature

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Date 3 / 24 / 06
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Atty. Docket 00684.163077A

Application No. 10/552,590

Sir:

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OIPE IAP46 MAR 24 2006 PATENT & TRADEMARK OFFICE

Atty. JBM/rm Due Date N / D / D
Mo. Day Yr.

FCHS-D-00

00684.103077A PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
: Examiner: Unassigned
NORIYUKI SHIKINA, ET AL.)
: Group Art Unit: Unassigned
Application No.: 10/552,590)
:
Filed: October 12, 2005)
:
For: ELECTROPHORETIC DISPERSION LIQUID AND ELECTROPHORETIC DISPLAY DEVICE) :) March 24, 2006

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST TO CONSOLIDATE APPLICATIONS AND REQUEST TO WITHDRAW PREVIOUSLY-FILED PETITION FOR EXPRESS ABANDONMENT

Sir:

Applicants respectfully request that the application papers filed on October 12, 2005, in the above-identified application be replaced with the application papers filed on October 19, 2005, in Application No. 10/553,625.

BACKGROUND

A first patent application, subsequently assigned U.S. Application No. 10/552,590, was filed on October 12, 2005, as a national stage application of International Application No. PCT/JP2004/0018433 It was discovered, however, that the specification and drawings contained incorrect pages.

Accordingly, Applicants subsequently filed a second patent application on October 19, 2005, assigned Application No. 10/553,625, with the intent of abandoning the first

application (the '590 application). The second application also claimed priority on PCT/JP2004/018433.

Applicants' representative has since been informed that, because of internal procedures at the U.S. Patent and Trademark Office, the second application cannot go forward because it claims the benefit of the same PCT application as the first application.

Accordingly, at the Examiner's request, Applicants are hereby requesting that the application papers filed in the second application replace those filed in the first application, and that the first application go forward.

In view of the request to go forward with the first application, Applicants also respectfully request that the Petition for Express Abandonment, filed November 17, 2005, be withdrawn.

Any fees necessary in connection with this paper may be deduced to Deposit Account No. 06-1205.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,

Scott D. Malpede
Attorney for Applicants
Registration No. 32,533

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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 00684.103077 U.S. /
INTERNATIONAL APPLICATION NO. PCT/JP2004/018433	INTERNATIONAL FILING DATE 03 December 2004 (03.12.04)	PRIORITY DATE CLAIMED 05 December 2003 (05.12.03)
TITLE OF INVENTION DISPLAY APPARATUS		
APPLICANT(S) FOR DO/EO/US NORIYUKI SHIKINA, ET AL.		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is attached hereto (required only if not communicated by the International Bureau).
   b. [ ] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern other document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A Preliminary Amendment.
14. [X] An Application Data Sheet under 37 CFR 1.76.
15. [ ] A substitute specification.
16. [ ] A power of attorney and/or change of address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.2 and 37 CFR 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the International Application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

U.S. APPLICATION NO.	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
New Applicat	PCT/JP2004/018433	00684.103077

21. The following fees are submitted:					
[X] a) Basic national fee			$300.00	$ 300.00	
[X] b) Examination fee			$200.00	$ 200.00	
[X] c) Search fee			$500.00	$ 500.00	
TOTAL OF ABOVE CALCULATION =			$1000.00	$1,000.00	
[ ] Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing or computer program listing filed in an electronic medium). The fee is $250 for each additional 50 sheets of paper or fraction thereof.					
Total Sheets	Extra sheets	Number of each additional 50 or fraction thereof (round up to a whole number)	RATE		
38 - 100 =	0/50 =	0	x $250.00		
Surcharge of **$130.00** for furnishing the oath or declaration later than 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$ 0	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	11-20 =	0	X $50.00	$ 0	
Independent Claims	2- 3 =	0	X $200.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $360.00	$ 360.00	
TOTAL OF ABOVE CALCULATIONS =				$1,360.00	
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.				$ 0	
SUBTOTAL =				$1,360.00	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$1,360.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0	
TOTAL FEES ENCLOSED =				$1,360.00	
				Amount to be refunded:	$
				Amount to be charged:	$

a. [X] A check in the amount of $ 1,360.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ______ in the amount of $________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 06-1205. A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:
Fitzpatrick, Cella, Harper & Scinto
30 Rockefeller Plaza
New York, NY 10112-3800
October 19, 2005

Scott D. Malpede
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32,533
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Form #119
SDM\mm
DC_MAIN 218545v1

JC12 Rec'd PCT/PTC 19 OCT 2005

DESCRIPTION

DISPLAY APPARATUS

[TECHNICAL FIELD]

The present invention relates to a display apparatus including a display panel having a multitude of pixels arranged in a matrix.

[BACKGROUND ART]

With development of information equipment, the needs for low-power and thin display apparatuses having grown, so that extensive study and development have been made on display apparatuses fitted to these needs.

Such a display apparatus is used frequently outdoors particularly as a wearable PC (personal computer) or an electronic note pad, thus being desirable that it can save power consumption and space. For this reason, e.g., such a product that a display function of a thin display such as a liquid crystal display and means for inputting coordinate data are integrated, and direct input can be effected by pressing a display item on a display surface with a stylus or finger, has been commercialized.

However, most of liquid crystal materials have no memory characteristic, so that it is necessary to

continuously apply a voltage to the liquid crystal during a display period. On the other hand, a liquid crystal material having a memory function cannot readily ensure a reliability in the case of assuming its use in various environments such as outdoor environment as in the wearable PC, thus failing to be put into practical use.

In view of these circumstances, as one of thin and light display apparatuses, an electrophoretic display apparatus has been proposed (U.S. Patent No. 3,612,758).

This type of electrophoretic display apparatus includes a pair of substrates disposed with a predetermined spacing therebetween, an insulating liquid filled in the spacing, a multiplicity of colored charged (migration) particles dispersed in the insulating liquid, and display electrodes disposed at each pixel along each substrate.

In this electrophoretic display apparatus, the colored charged particles are electrically charged positively or negatively, so that they are adsorbed by either one of the display electrodes depending on a polarity of a voltage applied to the display electrodes. As a result, e.g., it becomes possible to display various images by controlling a state in which the colored charged particles are adsorbed by the upper electrode and are observed from a viewer side

and a state in which the colored charged particles are adsorbed by the lower electrode, so that the color of the insulating liquid is visually identified. This type of the electrophoretic display apparatus is referred to as a vertical movement type electrophoretic display apparatus.

As another example of a conventional electrophoretic display apparatus, Japanese Laid-Open Patent Application (JP-A) No. Hei 9-211499 discloses such an electrophoretic display apparatus, different from the above described vertical movement type electrophoretic display apparatus in which the insulating liquid is sandwiched between the upper and lower electrodes, that a first electrode (common electrode) is disposed along a light-blocking layer located between adjacent pixels and second electrode (pixel electrode) is disposed over an entire pixel display portion and is covered with an insulating film.

For this reason, an insulating liquid is only required to be transparent, so that the display apparatus effects black display by covering the second electrode with electrophoretic particles and effects white display by collecting the electrophoretic particles to the first electrodes located between adjacent pixels to expose the second electrodes. As a result, by controlling a polarity of applied voltage pixel by pixels, it is possible to effect display of

an image.

Further, by using these display apparatuses and a so-called resistance film type coordinate position detection apparatus (digitizer) in combination it becomes possible to effect pen input or input by manual pressure sensing thereby to realize a paper like display apparatus which, e.g., permits the wearable PC of power and space saving type and can take notes.

However, the above described conventional electrophoretic display apparatuses generally have a low response speed, so that, e.g., in the case where high-speed response for pen input is required, a user feels inconformity due to the low response speed.

In order to solve this problem, it can be considered that the electrophoretic display apparatus described above is driven at a high voltage. In the case of simply performing high-voltage drive, e.g., it can be considered that the display apparatus is provided with high voltage drive ICs or high voltage TFTs (thin film transistors). However, these high voltage driver ICs or TFTs have been accompanied with problems such that they cause a large packaging scale and a high-cost structure.

[DISCLOSURE OF THE INVENTION]

The present invention has accomplished for

solving the above described problems.

An object of the present invention is to provide a display apparatus capable of being driven at a high voltage while suppressing increases in packaging scale and production costs.

Another object of the present invention is to provide a display apparatus having a high-speed display response characteristic.

According to an aspect of the present invention, there is provided a display apparatus, comprising: a display panel including pixels arranged in a matrix; pixel electrodes provided to the pixels, respectively, and a common electrode provided common to the pixels; scanning lines and signal lines for supplying a voltage to the pixel electrodes; a drive circuit connected to the common electrode, the scanning lines, and the signal lines; and a control circuit for providing a signal to the drive circuit. The control circuit selectively switches a display drive mode in which the display apparatus displays an image on the display panel through sequential scanning of the scanning lines and application of a variable voltage to pixels via the signal lines by the drive circuit and a rewriting drive mode in which the display apparatus rewrites a part of pixels into black or white through application of a voltage, which is higher than a range of the variable voltage, to the

part of pixels on a scanning line selected by the drive circuit.

In the display apparatus, the drive circuit may preferably selectively scans only a part of the scanning lines in the rewriting drive mode. In a further preferred embodiments, in the display drive mode, the drive circuit supplies a variable voltage to the pixel electrodes and a reference voltage to the common electrode, and in the rewriting drive mode, the drive circuit supplies the voltage higher than the range of the variable voltage to a pixel electrode of pixels to be rewritten, places a pixel electrode not to be rewritten in a high-impedance state, and supplies to the common electrode a voltage which is shifted from the reference voltage to an opposite-polarity side of the voltage supplied to the pixel electrode of pixels to be rewritten.

The display apparatus may further comprises an external input device, and when the display apparatus receives display information from a device other than the external input device, the control circuit selects the display drive mode to execute display of the display information on the display panel, and when the display apparatus received display information from the external input device, the control circuit selects the rewriting drive mode to execute display of the display information received from the external input

device.

The external input device may preferably be a position information input device superposed on the display panel, a pen input device or a handwriting input device.

The display apparatus may preferably be an electrophoretic display apparatus or a liquid crystal display apparatus.

According to another aspect of the present invention, there is provided an input apparatus, comprising: a display panel including pixels arranged in a matrix; pixel electrodes provided to the pixels, respectively, and a common electrode provided common to the pixels; scanning lines and signal lines for supplying a voltage to the pixel electrodes; a drive circuit connected to the common electrode, the scanning lines, and the signal lines; a control circuit for providing a signal to the drive circuit; and a position detection device for detecting a position designated by a pointing member, such as a pen, and outputting information on the detected position. When there is no output of the position detection device, the control circuit selects a display drive mode in which a gradation image is displayed on the display panel and the drive circuit applies a variable voltage to pixels through the scanning and data lines to display the gradation image

on the display panel, and when there is an output of the position detection device, the control circuit selects a rewriting drive mode in which a part of pixels of the display panel is rewritten into black or white and the drive circuit scans a part of the scanning lines and applies a voltage, which is higher than a range of the variable voltage, to a part of pixels to rewrite the part of pixels corresponding to the position designated by the pointing member.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Figures 1(a) to 1(h) are timing charts for illustrating various signal waveforms and optical responses in an embodiment of the display apparatus according to the present invention.

Figure 2 is a system block diagram of the display apparatus of the present invention.

Figure 3 is a schematic view showing an TFT backplane of the display apparatus of the present invention.

Figures 4(a) and 4(b) are schematic views each

showing one pixel portion, including electrophoretic particles, of the display apparatus of the present invention.

Figures 5(a) and 5(b) are graphs each showing a relationship between a voltage and an optical response characteristic at a pixel in an embodiment of the present invention.

Figures 6(a) to 6(h) are timing charts for illustrating various signal waveforms and optical responses in another embodiment of the display apparatus of the present invention.

[BEST MODE FOR CARRYING TO THE INVENTION]

Hereinbelow, embodiments of the present invention will be described with reference to the drawings.

(Embodiment 1)

Figure 2 is a block diagram showing a display apparatus system having functions of still image display, pen input, and pen input display.

As shown in Figure 2, the display apparatus system includes: a display module 217 including a display panel 10 having a laminated structure of an electrophoretic display device 215 and a TFT substrate (backplane) 214, circuits 212 - 214 for matrix drive, and a common electrode drive circuit 216; a display control module 218; an image memory (SDRAM) 211 for

display; a CPU 28; and peripheral memory circuits including a flash ROM 29 and an SDRAM 210.

To the display control module 218, an external input device (sensing device) 27 is connected. The external input device is a device for inputting positional information, such as a pen input apparatus.

The CPU 28 supplies control signals to the display control module 218 and the peripheral circuit blacks 29 and 210.

In the display control module 218, a graphic controller 21 takes in information stored in the internal memories (the memory 29 constituted by the flash ROM and the memory 210 constituted by the SDRAM) and image information through an external memory control circuit (external I/F) 25 for controlling input and output of data with an unshown external memory, a communication means 24 for forming the data input and output via a circuit connected to an external circuit, or a digitizer controller 23 for controlling a pen input tablet 27 as the external input device (sensing device). Further, the graphic controller 21 stores information to be displayed on the display portion 215 of the display panel 10 in a Video RAM (VRAM) 211 on the basis of the image information and transfers image data and control signals to the display module 217 via a panel controller 22 on the basis of the information in the

VRAM 211. The graphic controller 21 further produces necessary control signals, such as scanning selection signals for selecting and scanning gate lines, image information signals to be sent to a source line drive circuit, and Vsync and Hsync signals for providing transfer timing thereof, and sends the signals to the panel controller 22.

The panel controller 22 sends these control signals to respective drive circuits for the gate lines, source lines and the common electrode.

Power is supplied to the respective circuit blocks through a power management 26.

In the display module 217 described above, on the basis of the image data outputted from the panel controller 22 and the timing control signals such as Vsync and Hsync, desired voltages are supplied from the gate line drive circuit 213, the source line drive circuit 212, and the common electrode drive circuit 216 to the TFT backplane 214 of the display panel 10 including the TFT backplane 214 and the display portion 215. As a result, an electrophoretic state of particles in each pixel of the display portion 215 is changed to effect gradation display.

The display apparatus of this embodiment has two display modes including a gradation display mode and a binary display mode, as described in detail later. In the case of pen input, the binary display

mode is employed. For this reason, the above described source line drive circuit 212 has an output stage capable of selecting high impedance.

Hereinbelow, the display apparatus of this embodiment will be described as an electrophoretic display apparatus. However, the display apparatus of the present invention may be any display apparatus so long as it can be driven by a voltage. Accordingly, the display apparatus may be a liquid crystal display apparatus.

It is preferable that a voltage to be applied is variable so as to permit display of an intermediary state at multiple gradation levels. The display apparatus of the present invention is applicable to a so-called memory type display apparatus capable of retaining a written display state as it is without applying a voltage to pixel after completion of writing.

Figure 3 shows a schematic view of a portion of a TFT active matrix array with 300 rows and 250 columns in this embodiment.

Referring to Figure 3, the display panel 10 described above includes gate line electrodes (scanning electrodes) 33 and source line electrodes (data electrodes) 34 arranged in a matrix. A multitude of pixels are formed at respective intersections of these electrodes 33 and 34. The display panel 10

further includes TFTs 35, pixel electrode 36, and a common electrode (COM) 37 and is connected with the gate line drive circuit 213 for driving the gate line electrodes 33 and the source line drive circuit 212 for driving the source line electrodes 34. In this embodiment, a gate line driving voltage is +20 V with respect to an on-state voltage and -20 V with respect to an off-state voltage. A frame rate is 15 Hz. Further, a source line drive voltage Vw is 0 to 15 V, and a common electrode drive voltage Vcom is 30 to -15 V.

Figures 4(a) and 4(b) are schematic views each showing one pixel portion of the electrophoretic display apparatus in this embodiment. In these figures, black electrophoretic particles 63 are negatively charged electrically. In the case where, e.g., a first electrode 37 is a common electrode and a second electrode 36 is a pixel electrode, the pixel electrode 36 is covered with the black electrophoretic particles 63 to provide a black display state as shown in Figure 4(a) when a positive(-polarity) voltage is applied to the pixel electrode 36 with respect to the common electrode 37. On the other hand, when a negative(-polarity) voltage is applied to the pixel electrode 36 with respect to the common electrode 37, as shown in Figure 4(b), the black electrophoretic particles 63 are collected to the pixel electrodes 37

each located between adjacent pixels. As a result, the pixel electrode 36 is exposed, thus providing a white pixel state.

Figure 5(a) shows a voltage-optical response (reflectance) characteristic at pixel in this embodiment.

More specifically, when an initial display state is a white state, as indicated by a solid line, the voltage-reflectance characteristic is such that the display state is the white state at a voltage of not more than 0 V and is a black state at a voltage of not less than 15 V. Further, the voltage-reflectance characteristic when the initial display state is the black state is indicated by a dashed line.

Figure 5(b) shows a voltage-response time characteristic at pixel in this embodiment.

In this case, the response time is a time from start of the response to completion thereof from the white state to the black state. As shown in Figure 5(b), it can be understood that the response characteristic is improved with an increasing applied voltage. Incidentally, in the case of effecting 16 level gradation display, all the pixels are placed in the white state and then gradation control is effected in a source line drive voltage range (0 to 15 V). At that time, the Vcom is 0 V (grounding voltage).

As described above, to the display apparatus,

the external input device 27 (the positional information input device, such as the pen input apparatus) is connected. The pen input apparatus detects a position designated by a pen and outputs the detected position as digital information. The pen input apparatus (device) may be constituted by a pen and a special-purpose tablet but may be used as a pointing device such that it is formed of a transparent member and is superposed on the display panel, and an image on the display panel is overwritten with the pen or the picture area is scanned with the pen. In the case of lamination structure, the display panel is required to permit display of line image, such as a handwritten character inputted by the pen, with no delay.

Next, the pen input from the pen input tablet 27 will be considered. When the input is performed by designating a position on the tablet with the pen, it is assumed that additional writing is effected in the displayed picture image area. In this case, rewriting of display is required only with respect to the added portion with the pen. In other words, it is also possible to retain the display state as it is at a portion other than the added portion with the pen.

When the pen input is not performed, there is no output from the pen input table 27, so that the digitizing control circuit 23 transmit information

thereon to the graphic controller 21, which selects an ordinary display mode, i.e., a mode of displaying image information of the internal memories 29 and 210 and external image information received through the communication means 24. At that time, the gate line drive circuit 213 sequentially scans selectively the gate lines of the display panel, and the source line drive circuit 212 supplies a gradation signal voltage, depending on the image information, i.e., a variable voltage in such a range that it can vary from 0 to 15 V on the black display side and from 0 to -15 V on the white display side. A reference voltage is supplied from the common electrode drive circuit 216. These voltages are applied to the TFT backplane 214 to change an electrophoretic state of the electrophoretic particles in each pixel of the display portion 215. As a result, gradation display is performed.

When the pen input is effected, positional information depending on a position designated with the pen is sent from the pen input tablet 27 to the graphic controller 21 through the digitizing control circuit 24, and is written in the SDRAM 211 as the display memory. At this time, a flag is set at an SDRAM address of the written pixel so as to show that the pen input is effected at the address.

The graphic controller 21 sends the image information of the display memory to the display panel

217 but when the flag is set, the ordinary display mode is switched to such a display mode that scanning lines including the flagged portion are scanned on a priority basis. In this display mode, a rewriting operation of only the pen input portion is performed such that only the rewritten portion of the gate lines of the display panel 10 is scanned by the graphic controller 21. In this case, a black signal is sent to a source line of pixel to be rewritten and at the same time, a source line of pixel to be held in the previous display state is placed in a high-impedance state. The detailed writing operation will be described later.

Hereinafter, such a driving method during the pen input is referred to as "partial rewriting". The partial rewriting takes only a short time required to perform rewriting by partial scanning since the number of gate lines at a portion to be rewritten is smaller than the number of all the scanning lines, i.e., gate lines even in such a display panel having a large number of scanning (gate) lines. In the pen input device, in order not to provide inconformity to a user, a trail of the pen is required to be displayed with no interval on the picture area (screen). This can be realized by the partial rewriting.

Further, drawing of black line on white background is sufficient to write the handwriting

character in the picture area by pen input, so that only rewriting of pixel into the black state is required. As a result, it is not necessary to perform halftone display. The display apparatus of this embodiment provides high-speed responsiveness in such a rewriting operation that only the black display is performed.

Next, high-voltage drive during partial rewriting binary device will be described.

In order to explain the high-voltage drive during partial rewriting binary drive pixels "a" and "b" shown in Figure 3 are considered. In this case, it is assumed that pen input is performed at pixels located at intersections of s1 and g1 (pixel "a"), s2 and g2, and s3 and g3, that the pixel "a" is a pixel to be subjected to rewriting and the pixel "b" is a pixel to be held as it is, and that, as previous writing, control of pixel at a desired gradation level (a reflectance R1 at the pixels "a" and a reflectance R2 at the pixel "b") is completed and an optical response is kept constant.

Figures 1(a) to 1(h) show drive waveforms with respect to the pixels "a" and "b" and timing charts of optical responses at the pixels "a" and "b". More specifically, Figure 1(a) is a waveform of a voltage applied to the gate electrode g1 shown in Figure 3, Figure 1(b) is a waveform of voltage applied to the

source electrode s1 shown in Figure 3, Figure 1(c) is a waveform of a voltage applied to the source electrode s2 shown in Figure 3, Figure 1(d) is a waveform of a voltage applied to the common electrode shown in Figure 3, Figure 1(e) is a waveform of an interelectrode voltage (a potential difference between the pixel electrode 36 and the common electrode 37) at the pixel "a" shown in Figure 3, Figure 1(f) is a waveform of an interelectrode voltage at the pixel "b" shown in Figure 3, Figure 1(g) is an optical response at the pixel "a" shown in Figure 3, and Figure 1(h) is an optical response at the pixel "b" shown in Figure 3.

First, the pixel "a" (pixel to be subjected to rewriting) will be described.

An interelectrode voltage Vp at the pixel "a" shown in Figure 1(e) corresponds to a difference between a voltage Vwmax of the source electrode s1, at a time t1 at which the gate electrode g1 is in an ON state, and a common electrode voltage Vcom, i.e., Vp = Vwmax - Vcom. Here, the Vwmax is set to be a maximum voltage (15 V) which can be outputted from the source line drive circuit. At that time, the common electrode voltage Vcom is -15 V (0 V at the time of ordinal multi-level gradation display). Accordingly, it becomes possible to apply a larger voltage than that in the case of the ordinary multi-level gradation display by Vcom (-15 V). As a result, high-voltage

drive becomes possible and response at the pixel "a" is completed in a short time.

Next, the pixel "b" (pixel to be held as it is) will be described.

Ordinarily, an interelectrode voltage at the pixel "b" shown in Figure 1(f) corresponds to a difference between a voltage of the source electrode s2, at a time t1 at which the gate electrode g1 is in an ON state, and a voltage of the common electrode. IN this case, however, the source electrode s2 is in a high-impedance state as shown in Figure 1(c). Accordingly, there is no potential difference between the pixel electrode and the common electrode at the pixel "b" so that the interelectrode voltage at the pixel "b" is not changed irrespective of the Vcom value. In other words, at the pixel "b", the display state can be held as it is.

After the black is written with respect to the scanning line g1 by the above described drive, at a time t2, the scanning line g2 is selected and a voltage is applied similarly thereto. Thereafter, in a similar manner, only a selected scanning line is sequentially scanned.

As described above, the high-voltage drive during the partial rewriting binary drive is realized. Further, during this drive, it is also possible to scan the entire picture area but it becomes possible

to realize high-speed display response by scanning only scanning lines along pixel(s) to be subjected to rewriting.

According t this embodiment, the response performance of low response speed display device can be improved to permit pen input with no stress.

(Embodiment 2)

In this embodiment, the display apparatus of the present invention is applied to white/black binary display, and the display apparatus identical to that used in Embodiment 1 is used.

The pen input device is required to have a function of erasing an incorrectly-inputted line or drawing a trail of the pen by inverting white and black states of line even at a black background portion. In this case, it is necessary to effect white writing in pixel in addition to the black writing described in Embodiment 1. Further, when a part of an image displayed on the picture area (screen) is moved by dragging with the pen, white is written at a pixel where the image is completely moved as a background picture area. The display apparatus in this embodiment performs display response at high speed during white/black binary display, whereby it is also possible to effect binary motion picture display.

In order to explain display by binary half-toning (gradation representation), pixels "a" and

"b" shown in Figure 3 are considered. In this case, it is assumed that black is displayed at pixels located at intersections of s1 and g1 (pixel "a"), s2 and g2, and s3 and g3, that white is displayed at other pixels including the pixel "b", and that, an optical response is kept constant at pixel(s) where control thereof at a desired gradation level is completed.

Figures 6(a) to 1(h) show drive waveforms with respect to the pixels "a" and "b" and timing charts of optical responses at the pixels "a" and "b". More specifically, Figure 6(a) is a waveform of a voltage applied to the gate electrode g1 shown in Figure 3, Figure 6(b) is a waveform of voltage applied to the source electrode s1 shown in Figure 3, Figure 6(c) is a waveform of a voltage applied to the source electrode s2 shown in Figure 3, Figure 6(d) is a waveform of a voltage applied to the common electrode shown in Figure 3, Figure 6(e) is a waveform of an interelectrode voltage at the pixel "a" shown in Figure 3, Figure 6(f) is a waveform of an interelectrode voltage at the pixel "b" shown in Figure 3, Figure 6(g) is an optical response at the pixel "a" shown in Figure 3, and Figure 6(h) is an optical response at the pixel "b" shown in Figure 3. As shown in these figures, when the motion picture display is performed based on white/black two values, an image is formed in one frame divided into two

fields. Hereinbelow, a driving method in this embodiment will be described in detail.

First, field 1 will be described. The pixel "a" (pixel for displaying black) will be described. An interelectrode voltage Vblack at the pixel "a" shown in Figure 6(e) corresponds to a difference between a voltage Vwmax of the source electrode s1, at a time T11 at which the gate electrode g1 is in an ON state, and a common electrode voltage Vcom, i.e., Vblack = Vwmax - Vcom. Here, the Vwmax is set to be a maximum voltage (15 V) which can be outputted from the source line drive circuit. Accordingly, it becomes possible to apply a larger voltage than that in the case of the ordinary multi-level gradation display by Vcom (-15 V). As a result, high-voltage drive becomes possible and response at the pixel "a" is completed in a short time.

Next, the pixel "b" (pixel for displaying white) will be described. An interelectrode voltage at the pixel "b" shown in Figure 6(f) corresponds to a difference between a voltage of the source electrode s2, at a time T11 at which the gate electrode g1 is in an ON state, and a voltage of the common electrode. IN this case, however, the source electrode s2 is in a high-impedance state as shown in Figure 6(c). Accordingly, there is no potential difference between the pixel electrode and the common electrode at the pixel "b" so that the interelectrode voltage at the

pixel "b" is not changed irrespective of the Vcom value. In other words, at the pixel "b", the display state can be held as it is.

Next, field 2 will be described.

The pixel "a" (pixel for displaying black) will be described. As shown in Figure 6(b), the source electrode s1 is in a high-impedance state at a time T21 at which the gate electrode g1 is in an ON state. Accordingly, there is no potential difference between the pixel electrode and the common electrode at the pixel "a" so that the interelectrode voltage at the pixel "a" is not changed irrespective of the Vcom value. In other words, at the pixel "a", the black display state can be held as it is.

First, the pixel "b" (pixel for displaying white) will be described. An interelectrode voltage Vwhite at the pixel "b" shown in Figure 6(e) corresponds to a difference between a voltage Vwmin of the source electrode s2, at a time T21 at which the gate electrode g1 is in an ON state, and a common electrode voltage Vcom2, i.e., Vwhite = Vwmin - Vcom2. Here, the Vwmin is set to be a minimum voltage (0 V) which can be outputted from the source line drive circuit. Accordingly, it becomes possible to apply a larger voltage than that in the case of the ordinary multi-level gradation display by Vcom2 (30 V). As a result, high-voltage drive becomes possible and

response at the pixel "b" is completed in a short time.

By the above described driving method, a response performance of low response speed display device is improved to permit good motion picture display.

(Embodiment 3)

In this embodiment, a display apparatus has 16 gradation level display mode and a binary display mode and uses the binary display mode during pen input. A source line drive circuit has selectable output stages including a D/A converter output stage and an analog switch output stage. In the binary display mode, the analog switch output stage is employed. In this embodiment, the display apparatus is identical to that used in Embodiment 1 except for the source line drive circuit described above.

In the case of the 16 gradation level display mode, the D/A converter output stage is employed and a drive voltage has a maximum of 15 V and a minimum of 0 V. On the other hand, the analog switch output stage is employed when the binary display is performed, and a drive voltage is selectable between 30 V (ON state) and 0 V (OFF state) by switching.

In order to explain display by binary half-toning (gradation representation), pixels "a" and "b" shown in Figure 3 are considered. In this case, it is assumed that black is displayed at pixels located

at intersections of s1 and g1 (pixel "a"), s2 and g2, and s3 and g3, that white is displayed at other pixels including the pixel "b", and that, an optical response is kept constant at pixel(s) where control thereof at a desired gradation level is completed.

When the pen input is performed after completion of control of the pixels at a desired gradation level, e.g., in the analog switch mode, an ON voltage (30 V) is applied to the source electrode of the pixel "a" and an OFF voltage (0 V) is applied to the source electrode of the pixels "b". As a result, it becomes possible to apply to the pixel "a" a voltage higher than that in the case of the 16 gradation level display mode by 15 V. Thus, response at the pixel "a" is completed in a short time. To the pixel "b", the voltage of 0 V is applied but a resultant optical response level is kept constant based on a holding characteristic of the electrophoretic display device.

According to this embodiment, a response performance of low response speed display device is improved to permit pen input with no stress. Further, during the pen input, it is possible to realize a small-scale circuit by use of the analog switch output stage compared with such a circuit that the same level voltage is applied for drive by use of the D/A converter.

In the above described embodiments, the display apparatus of the present invention is described with respect to the electrophoretic display apparatus as an example but may be applicable to liquid crystal display apparatuses using a polymer network liquid crystal, a ferroelectric liquid crystal, etc. Further, the display apparatus of the present invention may also be applicable to both the horizontal movement type electrophoretic display apparatus and the vertical movement type electro-phoretic display apparatus. In the electrophoretic display apparatus, the electrophoretic particles and a dispersion medium may be encapsuled in a multitute of microcapsules.

[INDUSTRIAL APPLICABILITY]

As described hereinabove, according to the display apparatus of the present invention, in the case where a display state in a display panel is rewritten by binary gradation representation, it becomes possible to realize high-speed responsiveness by effecting drive at a voltage higher than a maximum drive voltage in multi-level display. Further, it is possible to realize a small packaging scale of a peripheral circuit and a reduction in production cost.

CLAIMS

1. A display apparatus, comprising:

a display panel including pixels arranged in a matrix,

pixel electrodes provided to the pixels, respectively, and a common electrode provided commonly to the pixels,

scanning lines and signal lines for supplying a voltage to said pixel electrodes,

a drive circuit connected to said common electrode, said scanning lines, and said signal lines, and

a control circuit for providing a signal to said drive circuit,

wherein said control circuit selectively switches a display drive mode in which said display apparatus displays an image on said display panel through sequential scanning of said scanning lines and application of a variable voltage to pixels via said signal lines by said drive circuit and a rewriting drive mode in which said display apparatus rewrites a part of pixels into black or white through application of a voltage, which is higher than a range of the variable voltage, to the part of pixels on a scanning line selected by said drive circuit.

2. An apparatus according to Claim 1, wherein said drive circuit selectively scans only a part of the scanning lines in the rewriting drive mode.

3. An apparatus according to Claim 1 or 2, wherein in the display drive mode, said drive circuit supplies a variable voltage to said pixel electrodes and a reference voltage to said common electrode, and in the rewriting drive mode, said drive circuit supplies the voltage higher than the range of the variable voltage to a pixel electrode of pixels to be rewritten, places a pixel electrode not to be rewritten in a high-impedance state, and supplies to said common electrode a voltage which is shifted from the reference voltage to an opposite-polarity side of the voltage supplied to the pixel electrode of pixels to be rewritten.

4. An apparatus according to any one of Claims 1 - 3, wherein said display apparatus further comprises an external input device, and when said display apparatus receives display information from a device other than the external input device, said control circuit selects the display drive mode to execute display of the display information on said display panel, and when said display apparatus

received display information from the external input device, said control circuit selects the rewriting drive mode to execute display of the display information received from the external input device.

5. An apparatus according to Claim 4, wherein the external input device is a position information input device superposed on said display panel.

6. An apparatus according to Claim 4 or 5, wherein the external input device is a pen input device or a handwriting input device.

7. An apparatus according to any one of Claims 1 - 6, wherein said display apparatus is an electrophoretic display apparatus.

8. An apparatus according to any one of Claims 1 - 6, wherein said display apparatus is a liquid crystal display apparatus.

9. An input apparatus, comprising:

a display panel including pixels arranged in a matrix,

pixel electrodes provided to the pixels, respectively, and a common electrode provided commonly to the pixels,

scanning lines and signal lines for supplying a voltage to said pixel electrodes,

a drive circuit connected to said common electrode, said scanning lines, and said signal lines,

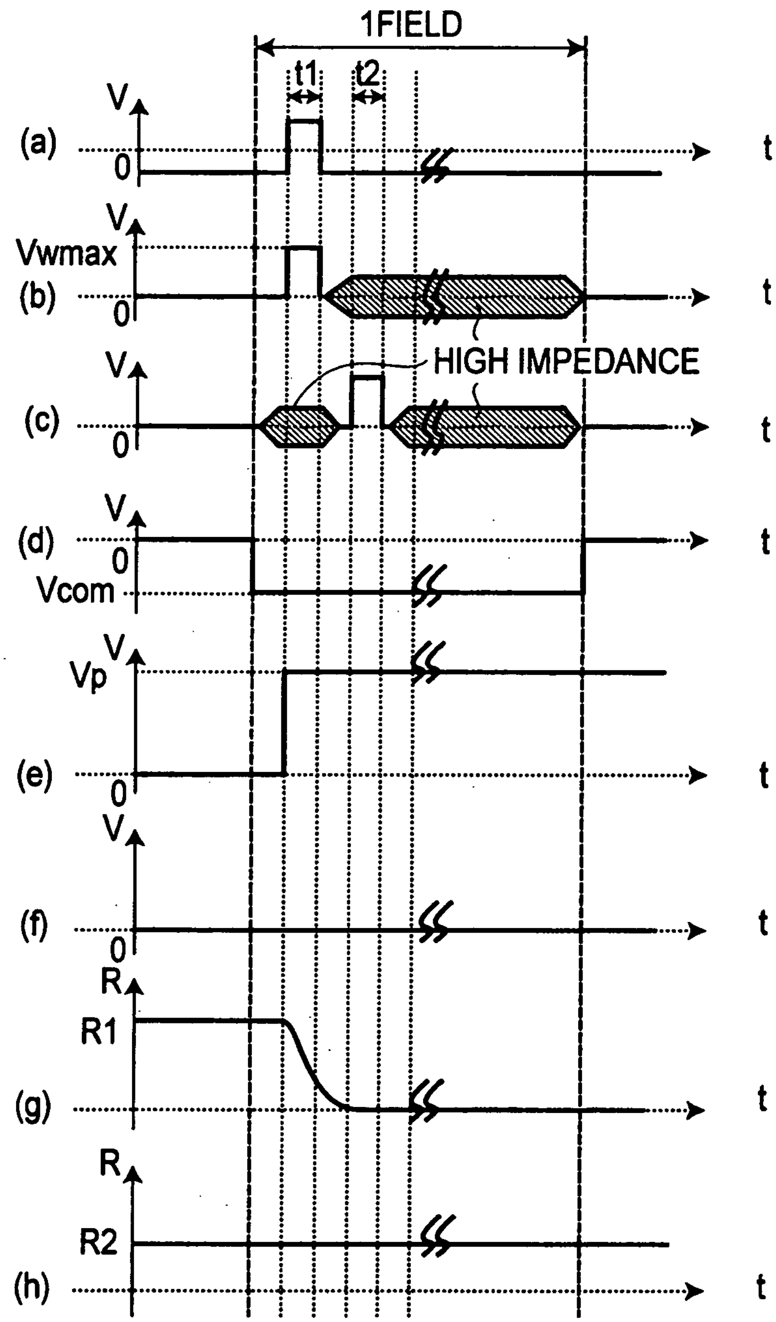
a control circuit for providing a signal to said drive circuit,

a position detection device for detecting a position designated by a positioning member and outputting information on the detected position,

wherein when there is no output of said position detection device, said control circuit selects a display drive mode in which a gradation image is displayed on said display panel and said drive circuit applies a variable voltage to pixels through said scanning and data lines to display the gradation image on said display panel, and when there is an output of said position detection device, said control circuit selects a rewriting drive mode in which a part of pixels of said display panel is rewritten into black or white and said drive circuit scans a part of said scanning lines and applies a voltage, which is higher than a range of said variable voltage, to a part of pixels to rewrite the part of pixels corresponding to the position designated by the pointing member.

ABSTRACT

An electrophoretic display apparatus includes a display panel 10 including gate line electrodes 33 and source line electrodes 34 arranged in a matrix to provide a multiplicity of pixels at respective intersections of these electrodes, a gate line drive circuit 213 for driving the gate line electrodes 33, and a source line drive circuit 212 for driving the source line electrodes 34. When a display state of the display panel 10 is partially rewritten, a reference voltage of a common electrode 37 is switched to a negative voltage Vcom on the basis of 0 V which is a reference voltage at the time of multi-gradation level display. As a result, the display apparatus can be driven at a high voltage to permit high-speed rewriting of the display panel, so that a display response characteristic in writing of white/black binary data or black writing by pen input is improved.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(a)
(b)
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(d)
(e)
(f)
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Vwmax
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Vcom
Vp
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R1
R2
t

FIG.1

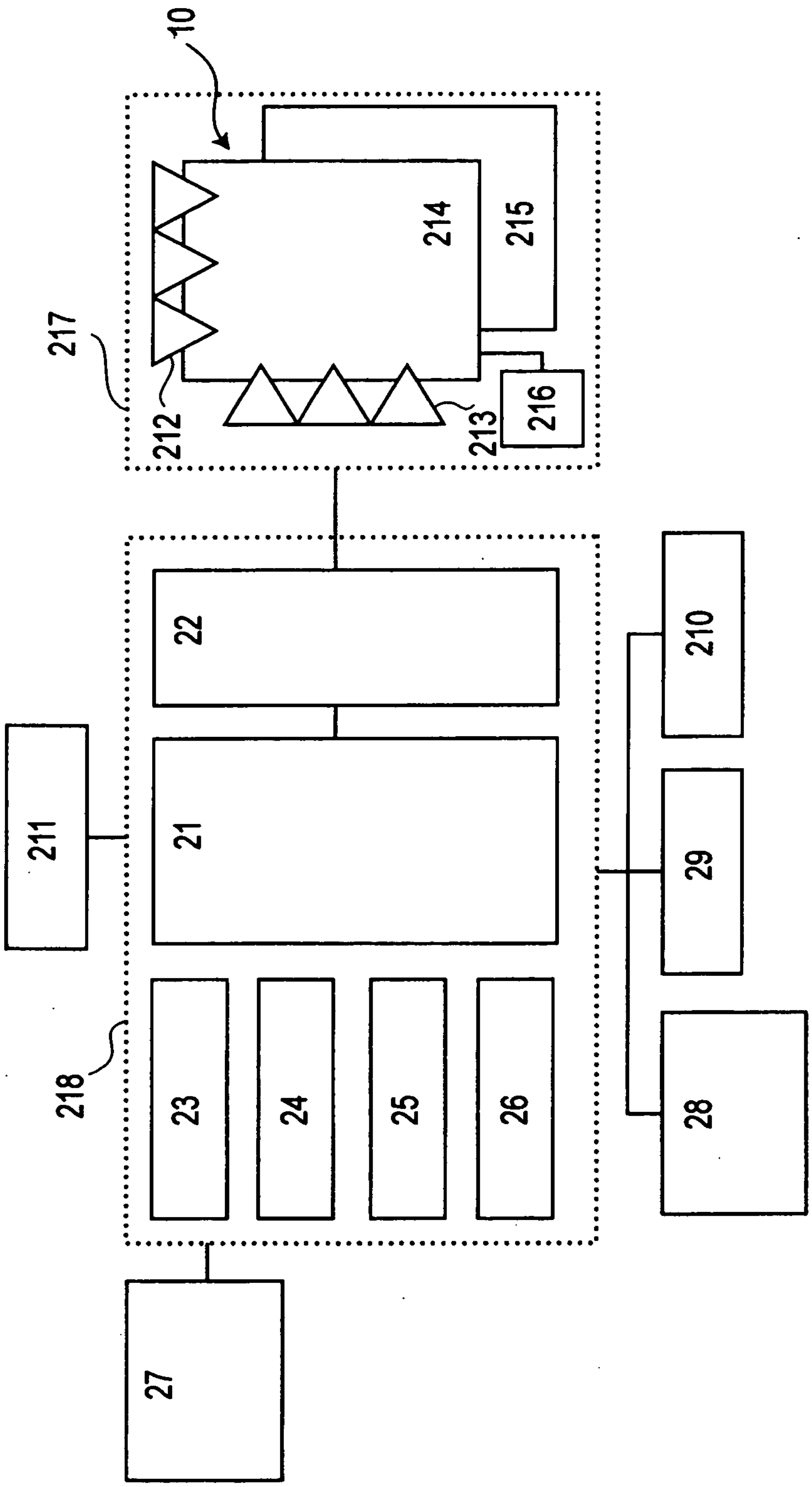

FIG.2

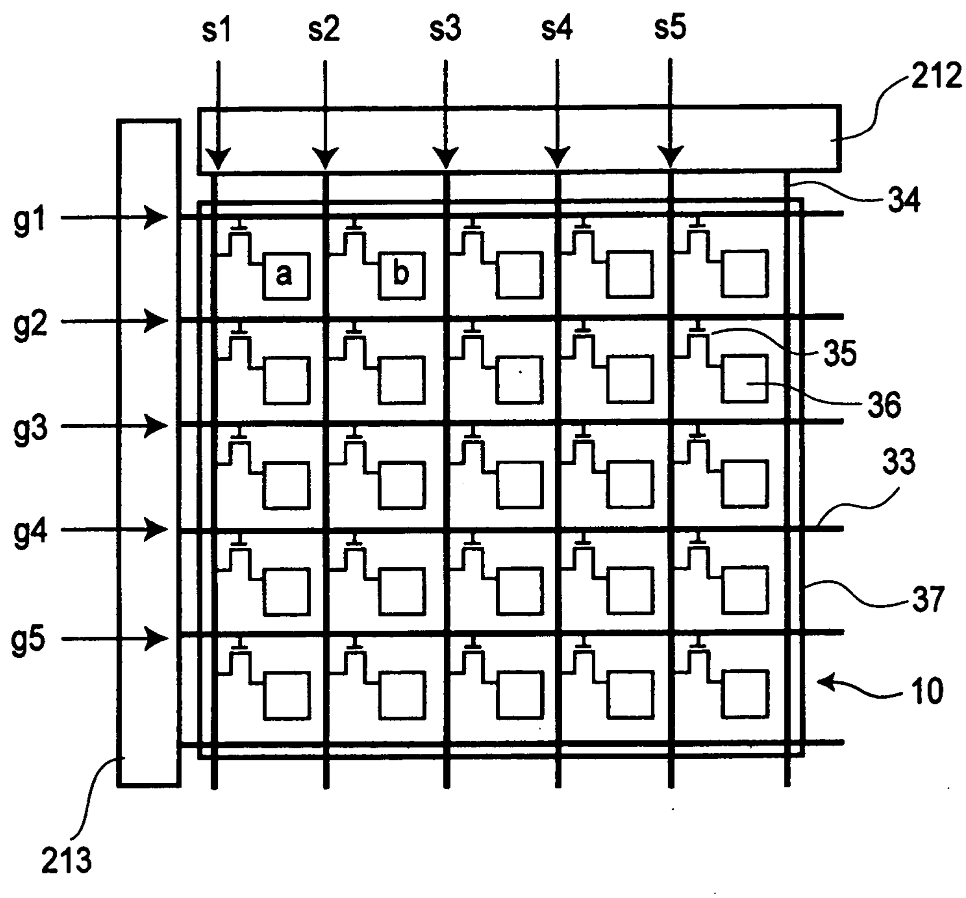

FIG.3

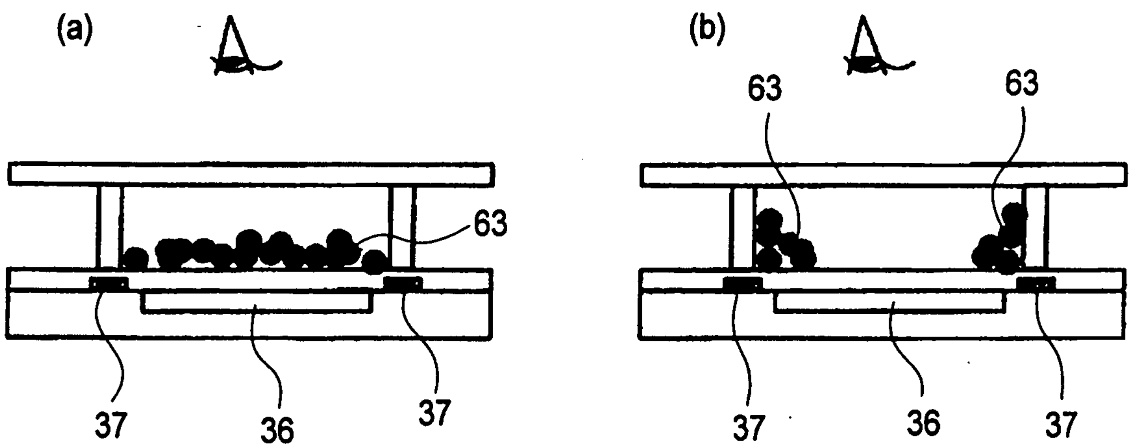

FIG.4

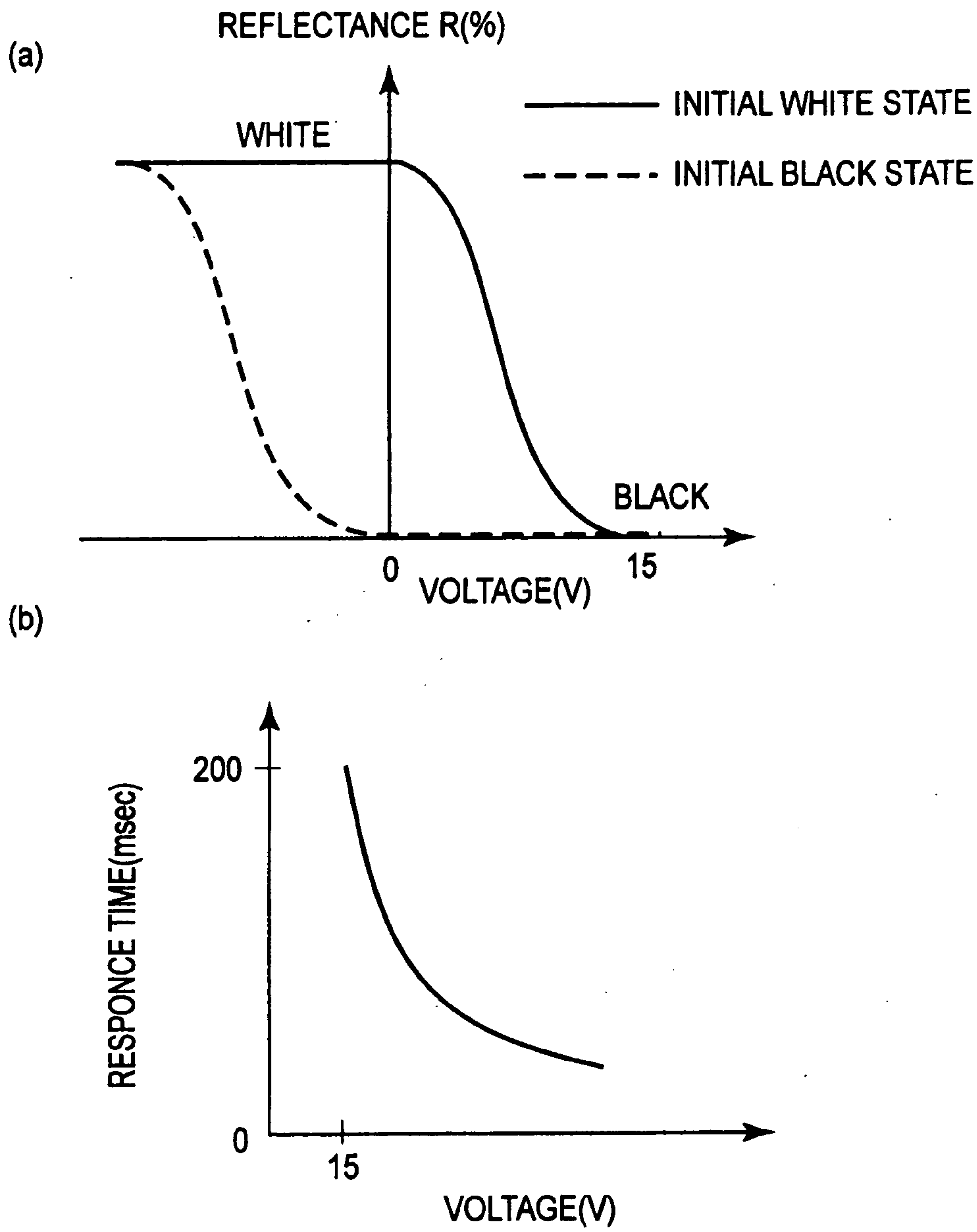
(a)
REFLECTANCE R(%)
WHITE
INITIAL WHITE STATE
INITIAL BLACK STATE
BLACK
0
15
VOLTAGE(V)
(b)
200
RESPONCE TIME(msec)
0
15
VOLTAGE(V)

FIG.5

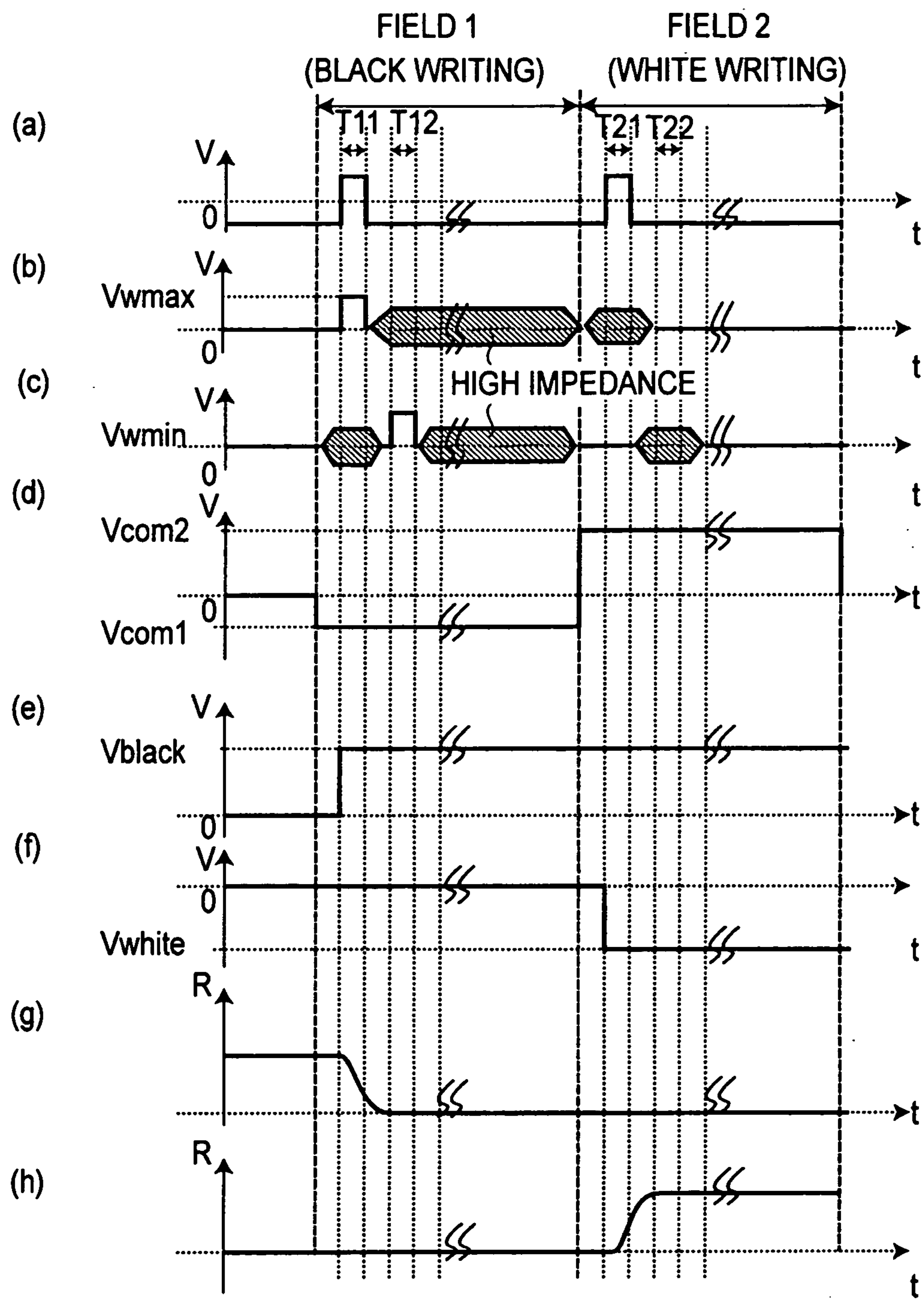
FIELD 1
(BLACK WRITING)
FIELD 2
(WHITE WRITING)
(a)
T11
T12
T21
T22
V
0
t
(b)
V
Vwmax
0
t
HIGH IMPEDANCE
(c)
V
Vwmin
0
t
(d)
V
Vcom2
0
Vcom1
t
(e)
V
Vblack
0
t
(f)
V
0
Vwhite
t
(g)
R
t
(h)
R
t

FIG.6

JC12 Rec'd PCT/PTO 19 OCT 2005

00684.103077

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	:	Examiner: Unassigned
NORIYUKI SHIKINA, ET AL.	)	
	:	Group Art Unit: Unassigned
Application No.: To Be Assigned	)	
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	:	
For: DISPLAY APPARATUS	)	October 19, 2005

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Sir:

In compliance with the duty of disclosure under 37 C.F.R. § 1.56 and in accordance with the practice under 37 C.F.R. §§ 1.97 and 1.98, the Examiner's attention is directed to the documents listed on the enclosed Form PTO-1449. Copies of the listed foreign documents are also enclosed.

For the Examiner's additional information, attached is a copy of the PCT International Search Report and the Written Opinion issued in connection with Applicants' corresponding PCT application.

JC1 Rec'd PCT/PTO 19 OCT 2005

CONCLUSION

Applicants request that the above information be considered by the Examiner and that an initialed copy of the enclosed Form PTO-1449 be initialed and returned indicating that such information has been considered.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

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FORM PTO 1449 (*modified*) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE LIST OF REFERENCES CITED BY APPLICANT(S) (Use several sheets if necessary) Submitted to the PTO: October 19, 2005	ATTY DOCKET NO. **00684.103077**	APPLICATION NO. **To be assigned** 10/553625
	APPLICANTS **NORIYUKI SHIKINA, ET AL.**	
	FILING DATE **October 19, 2005**	GROUP **To be assigned**

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		5,461,400	**10/1995**	**Ishii, et al.**	**345**	**182**	
		2003/0011869	**01/2003**	**Matsuda, et al.**	**359**	**296**	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES/NO/ OR ABSTRACT
		0 601 837	**06/1994**	**Europe**			
		WO 03/079176	**09/2003**	**PCT**			

OTHER DOCUMENT(S) (Including Author, Title, Date, Pertinent Pages, Etc.)

EXAMINER	DATE CONSIDERED

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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Sheet 1 of 1

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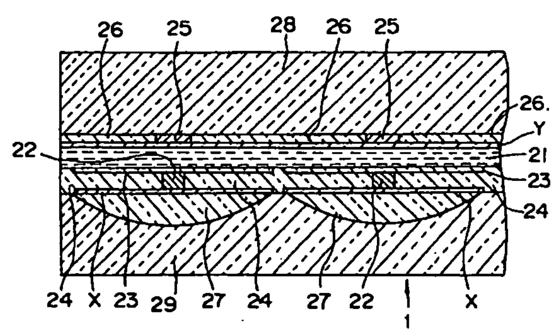
(54) Image input device-integrated type display device.

(57) There is provided an image input device-integrated type display device concurrently having an image display function, a document image input function, and a pen input function. A common electrode (Y) of the image input device-integrated type display unit (1) is formed on a glass plate (28). A segment electrode (X) is formed on a micro lens (27) of a glass plate (29). An island electrode (23) located at each pixel is connected to the segment electrode (X) via a photoconductor (22). Liquid crystals (21) are interposed between the common electrode (Y) and the island electrode (23). In an image input mode, light reflected on a document is applied to the photoconductor (22) to control a voltage applied to the liquid crystals (21). In a pen input mode, light from an input pen is applied to the photoconductor (22) to control a voltage applied to the liquid crystals (21). In an image display mode, a voltage applied to the liquid crystals (21) is controlled according to image data of each pixel. Thus brightness data of the document, position data of the input pen, and image data corresponding to a display signal are written into the image input device-integrated type display unit (1).

Fig.2



EP 0 601 837 A2

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image input device-integrated type display device for use in an information apparatus such as a personal computer, a word processor, or an electronic notebook.

2. Description of the Prior Art

Information apparatuses such as a personal computer and a word processor are demanded to be further compacted and have a higher performance. In recent years, liquid crystal display devices are increasingly used as a display unit for the information apparatuses in order to comply with the demand for compacting and reducing the weight of the apparatuses.

Besides, as a data input device for the above-mentioned information apparatuses, there are increasingly used an image scanner (for taking out an object image to be input as an electric signal) and a tablet (for designating an input position by means of a pen) other than a keyboard.

However, to constitute an apparatus having an image display function, image input function, and pen input function, there has been conventionally no way except for the method of combining independent hardware units of a display device, an image scanner, and a tablet.

When such independent hardware units are combined to constitute an apparatus, there are performed only data communications between the hardware units by means of electric signals, where the hardware units are not combined effectively and organically.

However, when independent hardware units of a display device, an image scanner, and a tablet are merely combined with each other to constitute an apparatus in a manner as described above, the resulting apparatus is inevitably dimensionally increased. Furthermore, even when the hardware units have therein common components, the components are to be redundantly used to result in significant wastefulness in terms of space and cost.

Particularly, the aforementioned image scanner is a bulky unit having a drive section, and therefore it is almost impossible to assemble an apparatus by integrating the image scanner with other hardware units.

SUMMARY OF THE INVENTION

The object of the present invention is therefore to provide a compact image input device-integrated type display device which concurrently has an image display function, a document image input function, and a pen input function.

In order to achieve the aforementioned object, there is provided an image input device-integrated type display device comprising: a display unit having a plurality of transparent segment electrodes arranged in parallel with each other on a transparent substrate; a plurality of transparent common electrodes arranged in parallel with each other on another transparent substrate, said common electrodes being perpendicular to said segment electrodes, a photoconductor electrically connected to either the segment electrode or the common electrode and arranged in a pixel composed of an area of intersection between the segment electrode and the common electrode, a transparent island electrode electrically connected to the photoconductor and arranged in between the segment electrode and the common electrode relevant to the pixel, liquid crystals interposed between the island electrode and an electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor, and a light shielding film for shielding only light entering from the side of the electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor so that the light does not reach the photoconductor; a display illumination light source which irradiates display illumination light in displaying an image on a pixel matrix composed of areas of intersections between the plural segment electrodes and the plural common electrodes of the display unit; a document illumination light source which irradiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit; a control light source which irradiates control light for optically controlling turning-on and turning-off of a voltage to be applied to liquid crystals of the display unit; a display control circuit which outputs a display signal for displaying an image on the pixel matrix of the display unit; an image input control circuit which outputs an image input signal for copying an optical image of the document into the pixel matrix of the display unit; an image read control circuit which outputs an image read signal for reading image data written in the liquid crystals of each pixel constituting the pixel matrix of the display unit in the form of an electric signal; a segment electrode drive circuit which drives the segment electrode based on the display signal from the display control circuit, the image input signal from the image input control circuit, or the image read signal from the image read control circuit; a common electrode drive circuit which drives the common electrode based on the display signal from the display control circuit, the image input signal from the image input control circuit, or the image read signal from the image read control circuit; an image data detection circuit which detects the image data written in the pixel matrix of the display unit in the form of an

electric signal; and a control circuit which copies the optical image of the document into the pixel matrix by controlling the image input control circuit, the document illumination light source, and the control light source in an image input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the image read control circuit, the image data detection circuit, and the control light source in an image read mode, and displays an image on the pixel matrix by controlling the display control circuit and the display illumination light source in an image display mode.

According to the above, at the pixel on which reflection light is incident from a white area of a document in the pixel matrix of the display unit set in the initial state under the control of a control circuit in the image input mode, the resistance of the photoconductor on which the reflection light strikes is made to have a low resistance, while a voltage is applied to the liquid crystals by the segment electrode drive circuit and the common electrode drive circuit based on the image input signal from the image input control circuit to thereby change the alignment state of the above-mentioned liquid crystals.

Thus, the optical image of the document is copied into the above-mentioned pixel matrix.

Furthermore, in the image read mode, the resistance of the photoconductor of the pixel on which the control light is incident under the control of the above-mentioned control circuit is made to have a low resistance, while a voltage based on the image read signal from the image read control circuit is applied to the segment electrode or the common electrode. Then the image data written in the above-mentioned pixel matrix are detected as an electric signal by the image data detection circuit.

Furthermore, in the image display mode, the resistance of the photoconductor of the pixel on which the display illumination light is incident under the control of the above-mentioned control circuit is made to have a low resistance, while a voltage based on the display signal from the display control circuit is applied to the aforementioned liquid crystals to thereby change the alignment state of the liquid crystals according to the above-mentioned display signal.

Thus, an image corresponding to the display signal from the above-mentioned display control circuit is written into the above-mentioned pixel matrix.

In an embodiment, phase transition type liquid crystals having a storage function are used as the liquid crystals.

According to the embodiment, in the aforementioned image input mode, the alignment state of the phase transition type liquid crystals is changed from the Grandjean state to the focalconic state and stored in the liquid crystals by the reflection light from the white area of the document to copy the optical image of the document into the above-mentioned pixel matrix. Furthermore, in the aforementioned image display mode, the alignment state of the phase transition type liquid crystals is changed into the above-mentioned Grandjean state or the focalconic state and stored in the liquid crystals according to the aforementioned display signal to write the image corresponding to the above-mentioned display signal into the above-mentioned pixel matrix.

Furthermore, the phase transition type liquid crystals exhibit a dielectric constant corresponding to the alignment state thereof. Therefore, in the aforementioned image read mode, a voltage signal which is, when a voltage is applied to one of the segment electrode and the common electrode, induced at the other electrode is detected by the aforementioned image data detection circuit to read the image data written in the pixel matrix as an electric signal.

In an embodiment, n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals having a storage function are used as the liquid crystals.

According to the embodiment, in the aforementioned image input mode, the alignment state of the n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals is changed from the Grandjean state to the focalconic state by the reflection light from the white area of the document. Furthermore, in the aforementioned image display mode, the alignment state of the n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals is changed to the Grandjean state or the focalconic state according to the above-mentioned display signal. Furthermore, in the aforementioned image read mode, a voltage signal which is, when a voltage is applied to one of the segment electrode and the common electrode, induced at the other electrode is detected by the aforementioned image data detection circuit.

There is provided an image input device-integrated type display device comprising: a display unit having a plurality of transparent segment electrodes arranged in parallel with each other on a transparent substrate; a plurality of transparent common electrodes arranged in parallel with each other on another transparent substrate, said common electrodes being perpendicular to said segment electrodes, a photoconductor electrically connected to either the segment electrode or the common electrode and arranged in a pixel composed of an area of intersection between the segment electrode and the common electrode, a transparent island electrode electrically connected to the photoconductor and arranged in between the segment electrode and the common electrode relevant to the pixel, liquid crystals interposed

between the island electrode and an electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor, and a polarizer for controlling a polarization direction of only light entering from a side of the electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor, said light being to able to reach the photoconductor when the light passed through the polarizer; a display illumination light source which irradiates display illumination light in displaying an image on a pixel matrix composed of areas of intersections between the plural segment electrodes and the plural common electrodes of the display unit; a document illumination light source which irradiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit; a control light source which irradiates control light for optically controlling turning-on and turning-off of a voltage to be applied to liquid crystals of the display unit; a display control circuit which outputs a display signal for displaying an image on the pixel matrix of the display unit; an image input control circuit which outputs an image input signal for copying an optical image of the document into the pixel matrix of the display unit; an image read control circuit which outputs an image read signal for reading image data written in the liquid crystals of each pixel constituting the pixel matrix of the display unit in the form of an electric signal; a segment electrode drive circuit which drives the segment electrode based on the display signal from the display control circuit, the image input signal from the image input control circuit, or the image read signal from the image read control circuit; a common electrode drive circuit which drives the common electrode based on the display signal from the display control circuit, the image input signal from the image input control circuit, or the image read signal from the image read control circuit; an image data detection circuit which detects the image data written in the pixel matrix of the display unit in the form of an electric signal; and a control circuit which copies the optical image of the document into the pixel matrix by controlling the image input control circuit, the document illumination light source, and the control light source in an image input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the image read control circuit, the image data detection circuit, and the control light source in an image read mode, and displays an image on the pixel matrix by controlling the display control circuit and the display illumination light source in an image display mode.

According to the above device, the polarization direction of only the light which enters from the side of the electrode which is one of the segment electrode and the common electrode of the display unit and is not electrically connected to the photoconductor is controlled by the polarizer before the light reaches the photoconductor. Therefore, the presence or absence of the light incident on the above-mentioned photoconductor from the above-mentioned electrode which is not electrically connected to the photoconductor is set by the above-mentioned polarizer.

As a result, when the operations of the above-mentioned image input mode, image read mode, and image display mode are executed in the same manner as in the aforementioned first device, the resistance of the photoconductor is also set by the light entering into the photoconductor from the electrode which is not electrically connected to the photoconductor to set the on/off condition of the voltage applied to the liquid crystals.

In an embodiment, ferroelectric liquid crystals are used as the liquid crystals.

According to the embodiment, in the aforementioned image input mode, the alignment state of the ferroelectric liquid crystals is changed from the state where they are perpendicular to (or in parallel with) the polarization direction of the polarizer to the state where they are in parallel with (or perpendicular to) the polarization direction of the polarizer by the reflection light from a white area of a document to copy the optical image of the document into the aforementioned pixel matrix. Furthermore, in the aforementioned image display mode, the alignment state of the ferroelectric liquid crystals is changed to the perpendicular state or to the parallel state according to the aforementioned display signal to write an image corresponding to the display signal into the above-mentioned pixel matrix. Furthermore, in the aforementioned image read mode, a specified voltage is applied to the above-mentioned ferroelectric liquid crystals to read the image data written in the above-mentioned pixel matrix as an electric signal by means of the image data detection circuit.

In an embodiment, the image data detection circuit detects a quantity of electric charges charged according to the image data at the island electrode of each pixel constituting the pixel matrix of the display unit, the control light source can irradiate light one by one on each electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor, and the control circuit reads the image data written in pixel matrix in the form of an electric signal by detecting a quantity of electric charges charged at the island electrode of the pixel relevant to the one segment electrode or common electrode which is selected by being irradiated by light of the control light source in the image read mode.

According to the embodiment, the island electrode which is in contact with the above-mentioned ferroelectric liquid crystals is charged with electric charges corresponding in quantity to the image data. Therefore, in the aforementioned image read mode,

a specified voltage is applied to the ferroelectric liquid crystals based on the image read signal from the image read control circuit to detect the quantity of electric charges charged at the island electrode at the pixel pertinent to the one segment electrode or common electrode which is selected by being subjected to irradiation of light from the control light source by the image data detection circuit.

Thus the image data written in the aforementioned pixel matrix are read as an electric signal.

In an embodiment, there is provided an input pen which has a light source and emits light from the light source outwardly through its tip end, and the control circuit controls the image input control circuit and the control light source in a pen input mode to allow an image input by means of the input pen to be written into the pixel matrix.

According to the embodiment, in the pen input mode, the pixel matrix of the display unit is set in the initial state under the control of the control circuit. Subsequently, the photoconductor of the pixel on which light directly from the light source of the input pen or reflection light is incident is made to have a low resistance, while a voltage based on the image input signal from the image input control circuit is applied to the liquid crystals to change the alignment state of the liquid crystals.

Thus, an image is written into the above-mentioned pixel matrix by the input pen.

In an embodiment, one of the two transparent substrates of the display unit is provided with a micro lens for condensing incident light thereto.

According to the embodiment, by virtue of the micro lens provided for one of the two transparent substrates of the aforementioned display unit, light which enters from the side of the transparent substrate at which the micro lens is not provided and is incident on the above-mentioned display unit is converged. Therefore, a sufficient quantity of light can be incident on the aforementioned photoconductor even when the quantity of light is reduced through reflection in, for example, the image input mode or the pen input mode.

Thus the brightness data of the document and the position data of the input pen are accurately written into the aforementioned pixel matrix.

In an embodiment, at least one of the two transparent substrates of the display unit is comprised of a plate-shaped optical fiber array where optical fibers each having a specified length are arranged two-dimensionally with axial directions of the optical fibers extended in a thickness direction of the optical fiber array.

According to the embodiment, light which is incident on the transparent substrate composed of a plate-shaped optical fiber array where optical fibers each having a specified length are arranged two-dimensionally with the axial directions of the optical fibers extended in the thickness direction of the optical fiber array travels through the above-mentioned optical fibers in the axial direction of the optical fibers. Thus the operation of each of the above-mentioned modes is executed without cross-talk between pixels nor loss in quantity of light.

In a embodiment the display illumination light source, the document illumination light source, and the control light source are comprised of one plate-shaped light source, and a side portion of the plate-shaped light source is pivotally mounted to a side portion of the display unit.

According to the embodiment, the aforementioned display unit is illuminated by the plate-shaped light source provided pivotally at a side of the display unit from the front surface or the back surface of the display unit at need. Thus the display illumination light source, the document illumination light source, and the control light source are concurrently provided by the above-mentioned one plate-shaped light source to execute the operation of each of the aforementioned modes.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1 is a schematic diagram of an image input device-integrated type display device in accordance with an embodiment of the present invention;

Fig. 2 is a sectional view of a part of an image input device-integrated type display device as shown in Fig. 1;

Fig. 3 is a graph showing a voltage-transmittance characteristic of phase transition type liquid crystals;

Fig. 4 is a graph showing a voltage-dielectric constant characteristic of phase transition type liquid crystals;

Figs. 5(a), 5(b) and 5(c) are diagrams for explaining an operation in an image input mode of an image input device-integrated type display device employing phase transition type liquid crystals;

Fig. 6 is a longitudinal section view of an input pen as shown in Fig. 1;

Fig. 7 is a diagram for explaining an operation in an image read mode of an image input device-integrated type display device employing phase transition type liquid crystals;

Fig. 8 is a diagram for explaining an operation in an image display mode of an image input device-integrated type display device employing phase transition type liquid crystals;

Figs. 9(a), 9(b), 9(c) and 9(d) are diagrams for ex-

plaining a change of the state of current/electric field effect type liquid crystals;

Fig. 10 is a sectional view of a part of an image input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 11(a), 11(b), 11(c) and 11(d) are diagrams for explaining an operation in an image display mode of an image input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 12(a), 12(b) and 12(c) are diagrams for explaining an operation in a pen input mode of an image input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 13(a), 13(b) and 13(c) are diagrams for explaining an operation in a document image read mode of an image input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 14(a), 14(b) and 14(c) are diagrams for explaining an operation in a document image read mode of an image input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 15 (a) and 15 (b) are diagrams for explaining an operation in an image read mode of an image input device-integrated type display device employing ferroelectric liquid crystals;

Figs. 16(a) and 16(b) are diagrams for explaining an operation in an image display mode of an image input device-integrated type display device employing ferroelectric liquid crystals;

Fig. 17 shows a perspective view of a part of a plate-shaped optical fiber array; and

Figs. 18(a), 18(b) and 18(c) are diagrams showing a relation in position between an image input device-integrated type display device of Fig. 1 and a back light.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following describes several embodiments of the present invention with reference to the attached drawings.

Fig. 1 is a schematic diagram of an image input device-integrated type display device of the present embodiment.

The present image input device-integrated type display device has several operation modes having the functions as follows. The operation modes are image display mode for writing an image into liquid crystals by means of an electric signal, a pen input mode for writing an image into liquid crystals by means of an input pen, an image input mode for directly copying an optical image of a document into liquid crystals, and an image read mode for reading an image written in liquid crystals in the pen input mode and the image input mode in the form of an electric signal.

Referring to Fig. 1, the above-mentioned image input device-integrated type display device comprises basically an image input device-integrated type display unit 1 composed of segment electrodes X_1, X_2, ... X_m (each of the segment electrodes indiscriminately referred to as X hereinafter) arranged in parallel in *m* columns and common electrodes Y_1, Y_2, ... Y_n (each of the common electrode indiscriminately referred to as Y hereinafter) arranged in parallel in *n* rows perpendicular to the segment electrode X and serving as an image input device, and a variety of peripheral circuits provided for the image input device-integrated display unit 1.

Each common electrode Y is connected to a common electrode drive circuit 2 and a common electrode selection circuit 4. On the other hand, each segment electrode X is connected to a segment electrode drive circuit 3.

A display control circuit 6 generates a display signal for displaying an image on liquid crystals interposed between the segment electrode X and the common electrode Y of the image input device-integrated display unit 1 by applying a voltage to the liquid crystals in the aforementioned image display mode. Furthermore, the display control circuit 6 generates an initialization signal for putting the above-mentioned liquid crystals into the initial state in the pen input mode or the image input mode.

An image data detection control circuit 7 generates an image read signal for reading an image written in the liquid crystals by applying a voltage to the segment electrode X of the image input device-integrated display unit 1 in the aforementioned image read mode.

An image input control circuit 8 generates an image input signal for writing an optical image of a document or a pen input image by applying a voltage to the liquid crystals by means of the segment electrode X and the common electrode Y of the image input device-integrated display unit 1 in the aforementioned image input mode or the pen input mode.

A switching circuit 5 switches between the display signal or the initialization signal from the aforementioned display control circuit 6, the image read signal from the image data detection control circuit 7, and the image input signal from the image input control circuit 8 to output the selected signal switchingly to the common electrode drive circuit 2 and the segment electrode drive circuit 3.

An image data detection circuit 9 detects a voltage induced at the common electrode Y of the image input device-integrated display unit 1 as image data in the image read mode.

An input pen 10 designates an input pixel when writing an image into the image input device-integrated display unit 1 in the pen input mode.

A back light 11 is controlled to be turned on and off and controlled of its position with respect to the image input device-integrated display unit 1 by a back light control circuit 12. The back light 11 irradiates light at need from the front or back side of the image input device-integrated display unit 1.

A control circuit 13 controls the display control circuit 6, image data detection control circuit 7, image input control circuit 8, image data detection circuit 9, and back light control circuit 12 to execute the operation in each of the image display mode, pen input mode, image input mode, and image read mode.

In more detail, the image input device-integrated display unit 1 constitutes the aforementioned display unit, and the image data detection control circuit 7 constitutes the image read control circuit.

The image input device-integrated type display device having the above-mentioned construction operates in the following manner in each of the operation modes under the control of the control circuit 13.

In the aforementioned image display mode, first the switching circuit 5 is switched to the display control circuit 6 to transmit the aforementioned display signal generated by the display control circuit 6 to the common electrode drive circuit 2 and the segment electrode drive circuit 3 via the switching circuit 5. Then the common electrode drive circuit 2 and the segment electrode drive circuit 3 scans the common electrode Y and the segment electrode X of the image input device-integrated display unit 1 to apply a voltage corresponding to the display signal to the liquid crystals of each pixel of a pixel matrix composed of the areas of intersections between the segment electrodes and the common electrodes. At the same time, the back light 11 is lit to display an image on the matrix of $n \times m$ pixels. In the above time, the polarities of the voltages applied to the segment electrode X and the common electrode Y are inverted every line or every frame in the same manner as in the general direct multiplexing matrix liquid crystal display device.

In the aforementioned image input mode, first the switching circuit 5 is switched to the display control circuit 6 side to transmit the initialization signal generated by the display control circuit 6 to the common electrode drive circuit 2 and the segment electrode drive circuit 3 via the switching circuit 5. Then the alignment state of the liquid crystals of the entire pixel matrix of the image input device-integrated display unit 1 is set in an initial state as described hereinafter.

Subsequently, the switching circuit 5 is switched to the image input control circuit 8 side to transmit the aforementioned image input signal generated by the image input control circuit 8 to the common electrode drive circuit 2 and the segment electrode drive circuit 3 via the switching circuit 5. Then a voltage for writing the optical image of a document is applied between the segment electrode X and the common electrode Y.

In the aforementioned pen input mode, first the switching circuit 5 is switched to the display control circuit 6 side to set the alignment state of the liquid crystals of the aforementioned pixel matrix in the initial state. Subsequently, the switching circuit 5 is switched to the image input control circuit 8 side to transmit the aforementioned image input signal generated by the image input control circuit 8 to the common electrode drive circuit 2 and the segment electrode drive circuit 3 via the switching circuit 5. Then a voltage for writing the position designated by the input pen 10 is applied to the segment electrodes and the common electrodes.

It is noted that the back light 11, which is not necessary in the above case, is unlighted.

In the aforementioned image read mode, the switching circuit 5 is switched to the image data detection control circuit 7 side to transmit the image read signal generated by the image data detection control circuit 7 to the segment electrode drive circuit 3 via the switching circuit 5. Then a voltage for reading an image is successively applied to each segment electrode X by the segment electrode drive circuit 3.

On the other hand, each common electrode Y is successively selected by the common electrode selection circuit 4, and an image signal induced at the selected common electrode Y is detected by the image data detection circuit 9 to be transmitted to the control circuit 13.

It is noted that the back light 11 irradiates light onto the image input device-integrated display unit 1 from behind the unit 1.

Then the following describes in detail the image input device-integrated display unit 1 which is an important component of the present invention.

Fig. 2 is a sectional view showing a part of an image input device-integrated type display unit 1 of the present embodiment taken along the common electrode Y. Referring to Fig. 2, there are provided liquid crystals 21, photoconductors 22, and island electrodes 23. There are further provided segment electrodes X and common electrodes Y.

The above-mentioned segment electrode X, common electrode Y, and island electrode 23 are transparent electrodes made of indium tin oxide (ITO). In Fig. 2, the segment electrodes X extend in a direction perpendicular to the plane of the paper on which Fig. 2 is illustrated, and transverse cross sections of two segment electrodes X exist. On the other hand, the common electrode Y extends in a direction parallel with the plane of the paper on which Fig. 2 is illustrated, and the longitudinal section of one common electrode Y exists. Hence an area of intersection between the segment electrode X and the common electrode Y constitutes a pixel.

The aforementioned island electrode 23 is pro-

vided for each pixel, and each island electrode 23 is surrounded by a transparent insulator 24. Therefore, island electrodes 23 are electrically isolated from each other.

The aforementioned photoconductor 22 has an infinitesimal section area and is arranged in an approximate center position of each pixel. The segment electrode X and the island electrode 23 constituting each pixel are electrically connected to each other by way of the photoconductor 22. The photoconductors 22 are surrounded by the above-mentioned transparent insulator 24.

The photoconductor 22 is a material of which resistivity changes when it receives light. The photoconductor 22 is made of cadmium sulfide (CdS), cadmium telluride (CdTe), selenium (Se), zinc sulfide (ZnS), bismuth silicate crystal (BSO), amorphous silicon, organic photoconductor, or the like.

The transparent insulator 24 for electrically isolating the photoconductors 22 is made of silicon oxide (SiO_2), titanium oxide (TiO_2), or an organic material such as resist.

There is formed a light-shielding film 25 on the common electrode Y above the photoconductor 22. The light-shielding film 25 prevents incident light through a glass plate 28 from directly entering into the photoconductor 22. The light-shielding film 25 is composed of a thin film made of aluminum (Al), tungsten (W), tungsten silicide (WSi), or the like.

A transparent insulator 26 is made of silicon oxide (SiO_2), titanium oxide (TiO_2), an organic material such as resist, or rubber for the purpose to flatten the unevenness generated due to the light-shielding film 25.

Each of glass plates 28 and 29 function as a transparent substrate for encapsulating the aforementioned liquid crystals 21. Therefore, the glass plates 28 and 29 may be each made of a transparent plastic plate or a transparent ceramic plate.

In a position corresponding to each pixel on the interior surface of the glass plate 29 is formed a micro lens 27 protruding into the glass plate 29. The micro lens 27 has a function of condensing incident illumination light transmitted through the glass plate 28 and light reflected on a document, and the convergent point of the lens is located at around the exterior surface of the glass plate 29. The micro lens 27 is formed by making the glass plate 29 have a refractive index distribution or a curved surface, or by bundling optical fibers.

The aforementioned liquid crystals 21 are composed of liquid crystals which have a storage function and exhibits a change of dielectric constant thereof between a state where they display a black color and a state where they display a white color (referred to merely as "between black and white colors" hereinafter). The following describes an example employing phase transition type liquid crystals.

The phase transition type liquid crystals are composed of p-type cholesteric liquid crystals or liquid crystals formed by mixing p-type cholesteric liquid crystals with p-type nematic liquid crystals. Fig. 3 shows a voltage-transmittance characteristic of liquid crystals of the above-mentioned type.

Referring to Fig. 3, in an initial state where an applied voltage is lower than "Vth1", the liquid crystals are in the Grandjean state where the helical axes of the cholesteric liquid crystal molecules are aligned in a direction perpendicular to the electrode surface. In the Grandjean state, incident light perpendicular to the electrode surface is transmitted. When the applied voltage is gradually increased above "Vth1", the liquid crystals are put into the focalconic state where the directions of the helical axes which have been aligned in a direction perpendicular to the electrode surface are disordered to be directed in irregular directions. In the focalconic state, the refractive index is disordered to diffuse light, with which the liquid crystals become turbid whitely.

Then, according as the applied voltage is further increased, the helical axis pitch of the cholesteric liquid crystals increases. When the applied voltage exceeds a threshold voltage "Vth2", the liquid crystals are transformed into nematic liquid crystals where liquid crystal molecules are aligned in the direction of an electric field (i.e., a homeotropic orientation). In the homeotropic orientation, the liquid crystals are optically transparent.

It is noted that the voltage to be applied to the liquid crystals may be an AC voltage or a DC voltage.

In order to store the state of the liquid crystals as described above, the applied voltage to the liquid crystals is required to be "0". For instance, when the applied voltage is made to be "0" in the focalconic state, the focalconic state is maintained and stored. When the applied voltage is abruptly made to be "0" in the homeotropic orientation state, the liquid crystals are transformed into the Grandjean state, and the Grandjean state is maintained and stored to maintain the transparent state.

The above-mentioned liquid crystals are dielectric substance, and therefore the liquid crystals exhibit a dielectric polarization when an electric field is applied to the liquid crystals. Fig. 4 shows a change of dielectric constant between black and white colors corresponding to the state of the liquid crystals as shown in Fig. 3. Referring to Fig. 4, the dielectric constant increases while the liquid crystals are transformed from the Grandjean state via the focalconic state to the homeotropic orientation.

As liquid crystals which have the above-mentioned storage function and exhibit a change of dielectric constant between black and white colors, there are liquid crystals of a type which is to be subjected to a write operation by a current effect and an erasing operation by an electric field effect (the liquid crystals referred to as the "current/electric field ef-

fect type liquid crystals" hereinafter) such as n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, and smectic-A liquid crystals, and ferroelectric liquid crystals other than the above-mentioned phase transition type liquid crystals.

First Embodiment

Then the following describes the principle of operation of the image input device-integrated display unit 1 employing phase transition type liquid crystals as the liquid crystals 21 in regard to each of the aforementioned modes with reference to Figs. 5 through 8.

(1) Image input mode (in which the optical image of a document is optically written directly into the image input device-integrated display unit)

In a first step, the liquid crystals 21 are entirely put into a transparent state (i.e., into the aforementioned Grandjean state) (Fig. 5 (a)).

Control light is irradiated on the entire surface of the liquid crystals by the back light 11 from the side of the glass plate 29, and a voltage which is not lower than "Vth2" is applied across segment electrodes X and common electrodes Y from a power source 30 based on the aforementioned initialization signal from the display control circuit 6. In the above time, a voltage may be successively applied to each segment electrode X and each common electrode Y, or simultaneously applied to all the segment electrodes X and all the common electrodes Y.

Thus the photoconductor 22 is made to have a low resistance by the incident light from the side of the glass plate 29, with which the segment electrode X and the island electrode 23 connected to the photoconductor 22 are made to have an approximately equal potential. Consequently, a voltage approximately equal to the voltage "Vth2" supplied from the power source 30 (the voltage is slightly reduced by a voltage drop due to the photoconductor 22) is applied to the liquid crystals 21, with which the liquid crystals 21 are put into the homeotropic orientation.

Subsequently, when the voltage applied across the above-mentioned segment electrode X and the common electrode Y is abruptly made to be "0", the liquid crystals 21 are restored from the homeotropic orientation to the Grandjean state to maintain a transparent state. Then the control light from the side of the glass plate 29 is turned off.

Thus the liquid crystals 21 are entirely put into a transparent state to put the liquid crystals 21 into the initial state before image input.

In a second step, reflection light from a document 31 is copied into the liquid crystals 21 (refer to Figs. 5 (b) and 5 (c)).

The document 31 is placed under the glass plate 29 with the document substantially closely fit to the glass plate 29. Based on an image input signal from the image input control circuit 8, a voltage which is not lower than "Vth1" and lower than "Vth2" is applied across each segment electrode X and each common electrode Y from the power source 30. In the above time, a voltage may be successively applied to each segment electrode X and each common electrode Y, or simultaneously applied to all the segment electrodes X and all the common electrodes Y.

Then document illumination light is irradiated on the entire surface of the glass plate 28 by the back light 11 from the glass plate 28 side. Since the liquid crystals 21 have been already made to be transparent in the aforementioned first step, the document illumination light incident on the glass plate 28 reaches the micro lens 27 by way of the transparent insulator 26, common electrode Y, liquid crystals 21, island electrode 23, transparent insulator 24, and segment electrode X except for the area of the light-shielding film 25. Then the light is converged on the document 31 by the micro lens 27.

In the case where the convergence light strikes on a white area of the document 31, the light is reflected on the white area as shown in Fig. 5 (b). A part of the reflection light is transmitted through the segment electrode X to be incident on the photoconductor 22.

Then the photoconductor 22 on which the light strikes is made to have a low resistance, with which the segment electrode X and the island electrode 23 connected to the photoconductor 22 are made to have an approximately equal potential.

Consequently, a voltage approximately equal to the voltage which is not lower than "Vth1" and lower than "Vth2" applied across the segment electrode X and the common electrode Y is applied across the island electrode 23 and the common electrode Y. Therefore, the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which the light strikes are transformed from the initial Grandjean state into the focalconic state to be turbid whitely.

In other words, the white area of the document 31 is invertedly written into the liquid crystals 21 as a black area.

In contrast to the above, in the case where the convergence light strikes on a black area of the document 31, no light is reflected on the black area as shown in Fig. 5 (c), and therefore no light strikes on the photoconductor 22. Therefore, the photoconductor 22 on which no light strikes remains having a high resistance.

In the above case, by setting the resistance of the photoconductor 22 in condition where no light strikes on it (the resistance in this condition referred to as the "dark resistance" hereinafter) at a value sufficiently higher than the resistance of the liquid crys-

tals 21, almost no voltage is applied across the island electrode 23 and the common electrode Y because of a significant voltage drop across the segment electrode X and the island electrode 23.

Consequently, a voltage which is lower than "Vth1" is applied across the island electrode 23 and the common electrode Y. Therefore, the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which no light strikes maintain the initial Grandjean state to be transparent.

In other words, the black area of the document 31 is invertedly written into the liquid crystals 21 as a white area.

Thus in the image input mode, a negative image of the document 31 is written into the matrix of $n \times m$ pixels of the image input device-integrated display unit 1.

In order to store the optical image of the document 31 which has thus written in the pixel matrix of the image input device-integrated display unit 1 into the liquid crystals 21, the voltage applied across the segment electrode X and the common electrode Y from the power source 30 is required to be "0", and the document illumination light is required to be removed.

The image input mode is described above by exemplifying the case where the optical image of the document 31 is stored into the liquid crystals 21 by means of the reflection light from the document 31. However, the image input device-integrated display unit 1 of the present embodiment can store the optical image of the document 31 into the liquid crystals 21 by means of a transmission light from a transparent document.

The following describes the image input mode using a transparent document.

In order to write the optical image of the transparent document into the liquid crystals 21, the transparent document is placed under the glass plate 29, and document illumination light is radiated by the back light 11 from under the transparent document. In the above case, either a negative image or a positive image of the document can be written into the aforementioned pixel matrix.

In the case where the negative image is written, a voltage which is not lower than "Vth1" and lower than "Vth2" is applied across the segment electrode X and the common electrode Y from the power source 30 with the initial state set in the Grandjean state in the same manner as in the aforementioned case where the optical image of the document 31 is stored into the liquid crystals 21 by means of the reflected light from the document 31.

A part of light transmitted through a transparent portion of the transparent document is transmitted through the segment electrode X to strike on the photoconductor 22. Consequently, a voltage approximately equal to the voltage which is not lower than "Vth1" and lower than "Vth2" and is applied across the segment electrode X and the common electrode Y is applied to the liquid crystals 21, with which the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which the light strikes are transformed from the initial Grandjean state to the focalconic state to be turbid whitely.

In other words, the transparent area of the above-mentioned transparent document is invertedly written and stored into the liquid crystals 21 as a black area.

In contrast to the above, the photoconductor 22 which is shielded from the document illumination light by an opaque portion of the document remains having a high resistance. Consequently, a voltage which is lower than "Vth1" is applied to the liquid crystals 21, while the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which no light strikes maintain the initial Grandjean state to be transparent.

In other words, the opaque area of the above-mentioned transparent document is invertedly written and stored into the liquid crystals 21 as a white area.

Thus the negative image of the above-mentioned transparent document is written into the pixel matrix of the image input device-integrated display unit 1.

Then the following describes the case where the aforementioned positive image is written.

In order to write the positive image, a voltage which is not lower than "Vth2" is applied across the segment electrode X and the common electrode Y from the power source 30 with the initial state set in the focalconic state (where the liquid crystals are turbid whitely).

Then a part of light transmitted through a transparent portion of the above-mentioned transparent document is transmitted through the segment electrode X to strike on the photoconductor 22. Consequently, a voltage approximately equal to the voltage which is not lower than "Vth2" and is applied across the segment electrode X and the common electrode Y is applied to the liquid crystals 21, with which the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 on which the light strikes are transformed from the initial focalconic state to the homeotropic orientation to be transparent.

In other words, the transparent area of the above-mentioned transparent document is written and stored into the liquid crystals 21 as a white area.

In contrast to the above, the photoconductor 22 which is shielded from the document illumination light by an opaque portion of the above-mentioned transparent document remains having a high resistance. Consequently, a voltage which is lower than the "Vth2" is applied to the liquid crystals 21. In the above case, by setting the dark resistance of the photocon-

ductor 22 at a value such that the voltage across the island electrode 23 and the common electrode Y is not lower than "Vth1" and lower than "Vth2", a voltage which is not lower than "Vth1" and lower than "Vth2" and is applied to the liquid crystals 21.

Therefore, the liquid crystals 21 constituting the pixels in the area of the photoconductor 22 which is shielded from the document illumination light maintain the initial focalconic state to be turbid whitely.

In other words, the opaque area of the above-mentioned transparent document is written and stored into the liquid crystals 21 as a black area.

Thus the positive image of the above-mentioned transparent document is written into the pixel matrix of the image input device-integrated display unit 1.

It is noted that the light-shielding film 25 is not necessary when the optical image of the above-mentioned transparent document is written into the pixel matrix of the image input device-integrated display unit 1.

The control light and the document illumination light in the case where the optical image of the document 31 is stored into the liquid crystals 21 by means of the reflection light from the document 31 are obtained by moving the back light 11 on the side of the glass plate 28 or on the side of the glass plate 29 of the image input device-integrated display unit 1 as described in detail hereinafter.

(2) Pen input mode (in which an image is written into the image input device-integrated display unit by means of an input pen which emits light)

Fig. 6 shows a sectional view of the above-mentioned input pen 10. The input pen 10 has a built-in light source 41 composed of an LED (Light-Emitting Diode), a semiconductor laser, an EL (Electro Luminescence), or the like. Light emitted from the light source 41 is conducted to the tip of the pen by way of a photoconducting path 42 composed of a plastic fiber or the like. The photoconducting path 42 is covered with a sleeve 43, where the tip of the sleeve 43 is slightly protruding from the tip of the photoconducting path 42.

An axially inward end of the sleeve 43 is fitted to an end of a spring 44. The other end of the spring 44 is put in contact with a pen touch switch 45. With the above-mentioned arrangement, when the tip of the input pen 10 (i.e., the tip of the sleeve 43) is pressed, the pen touch switch 45 is turned on to be able to discriminate whether the operator is in an input operation.

A pen control circuit 46 makes the light source 41 emit light by transmitting a light source control signal upon reception of an "on signal" (referred to as a "touch signal" hereinafter) from the pen touch switch 45. It is noted that a power is supplied from a small-size battery 47 to the pen control circuit 46.

A casing 48 has a cylindrical configuration to serve as an exterior wall which supports the sleeve 43 with its conical end portion and fixes the above-mentioned light source 41, spring 44, pen touch switch 45, pen control circuit 46, and small-size battery 47.

The pen input mode operation is executed in the same manner as in the case where the optical image in the white area of the document 31 is written into the liquid crystals. The following describes the operation with reference to Fig. 5 (b).

After the liquid crystals 21 of the image input device-integrated display unit 1 are put into an initial state (Grandjean state: transparent state), a voltage which is not lower than "Vth1" and lower than "Vth2" is applied across the segment electrode X and the common electrode Y from the power source 30 based on the image input signal from the image input control circuit 8. On the other hand, a white sheet is placed under the glass plate 29 with the sheet substantially closely fit to the glass plate 29.

Now the tip of the input pen 10 is placed in an area on the glass plate 28 corresponding to the write pixels of the pixel matrix of the image input device-integrated display unit 1, and then the casing 48 of the input pen 10 is pressed against the glass plate 28. By so doing, the pen touch switch 45 is turned on to make the light source 41 emit light.

Then, the light conducted from the light source 41 to the photoconducting path 42 is emitted from the tip of the sleeve 43 to enter into the image input device-integrated display unit 1. The light which is converged by the micro lens 27 and transmitted through the image input device-integrated display unit 1 is reflected on the white sheet to strike on the photoconductor 22. Consequently, the resistance of the photoconductor 22 is reduced, and a voltage which is not lower than "Vth1" and lower than "Vth2" is applied to the liquid crystals 21 constituting the relevant pixel to thereby transform the liquid crystals 21 into the focalconic state (where the liquid crystals are turbid whitely).

Subsequently, when the input pen 10 is moved out of the relevant pixel area or the input pen 10 is put apart from the image input device-integrated display unit 1 to turn off the pen touch switch 45, no light is incident on the relevant pixel to make the resistance of the photoconductor 22 be the dark resistance. Consequently, a great voltage drop takes place at the photoconductor 22 with which the voltage applied to the liquid crystals 21 is made to be "0".

Thus the liquid crystals 21 in the relevant pixel area put in the focalconic state by the pen input maintain the focalconic state. In other words, dark data are written into the liquid crystals 21 in the relevant pixel area by the pen input.

By drawing a character or a figure on the image input device-integrated display unit 1 by means of the input pen 10 in the above-mentioned manner, the

character or figure is written into the pixel matrix.

In the above case, by time-sharingly processing the above-mentioned pen input mode and the image read mode described in detail hereinafter, the coordinates of the pixel currently designated by the input pen 10 can be detected.

In the above-mentioned pen input mode, a part of image already written in the pixel matrix of the image input device-integrated display unit 1 can be erased.

In order to do so, a voltage which is not lower than "Vth2" is applied across the segment electrode X and the common electrode Y from the power source 30. By tracing the line which is desired to be erased by means of the input pen 10, the liquid crystals 21 in the relevant pixel area in which the dark data pertinent to the objective line to be erased are written is transformed from the focalconic state to the homeotropic orientation.

Thus the dark data written in the liquid crystals 21 in the relevant pixel area are rewritten into light data to erase the objective line to be erased.

(3) Image read mode (in which an image written in the image input device-integrated display unit is read as an electric signal)

Fig. 7 is a schematic sectional view of the above-mentioned image input device-integrated display unit 1, where elements irrelevant to the image read mode are eliminated.

The liquid crystals 21 of the pixels constituting the pixel matrix of the image input device-integrated display unit 1 are in the Grandjean state, focalconic state, or a state between them according to the brightness data written in the image input mode or the pen input mode.

Control light is irradiated by the back light 11 from the side of the glass plate 29. Then the incident light strikes on the photoconductor 22 to make the photoconductor 22 have a low resistance.

In the above-mentioned condition, each segment electrode X is successively scanned by successively applying pulses of a voltage which is not higher than "Vth1" to the segment electrodes ..., X_a, X_b, X_c, X_d, ... by means of the segment electrode drive circuit 3 based on image read data from the image data detection control circuit 7. Since the photoconductor 22 has a low resistance in the above case, island electrodes ... 23_a, 23_b, 23_c, 23_d, connected to the segment electrode X via each photoconductor 22 are scanned by the pulses of the voltage which is not higher than "Vth1".

Thus the pulses of the voltage which is not higher than "Vth1" are successively applied to the liquid crystals 21 of pixels in each column of the aforementioned pixel matrix, where the alignment state of the liquid crystals 21 is not changed by the voltage.

The common electrode Y and the island electrode 23 arranged with interposition of the liquid crystals 21 being a dielectric substance are electrostatically coupled. Therefore, a voltage is induced at the common electrode Y due to the pulse voltage applied to the island electrode 23. In the above case, the magnitude of the induction voltage corresponds to the electrostatic capacitance across the island electrode 23 and the common electrode Y. In other words, the greater the electrostatic capacitance across the island electrode 23 and the common electrode Y is, the greater the voltage induced at the common electrode Y will be.

Since the distance between the island electrode 23 and the common electrode Y is constant, the electrostatic capacitance across the island electrode 23 and the common electrode Y varies according to the dielectric constant of the liquid crystals 21. The dielectric constant of the liquid crystals 21 varies according to the alignment state of the liquid crystal molecules as shown in Fig. 4. According to the alignment state of the liquid crystal molecules, the brightness condition to be written is determined. Therefore, the alignment state (i.e, brightness condition) of the liquid crystals 21 can be detected by detecting the voltage induced at the common electrode Y. The voltage signal induced at the common electrode Y is amplified and shaped by the image data detection circuit 9.

Thus the brightness data written into each pixel of the pixel matrix of the image input device-integrated display unit 1 are read as an induction voltage at the common electrode Y.

Specifically, a voltage which is not higher than "Vth1" is successively applied to the segment electrodes X_1 through X_m by means of the segment electrode drive circuit 3 in the period when the common electrode Y_1 is selected by the common electrode selection circuit 4 as shown in Fig. 1 to transmit the time series of the read induction voltage pertinent to all the pixels of the common electrode Y_1 to the image data detection circuit 9.

When the brightness data of the pixels in the 1st row and *m* columns are read in the above-mentioned manner, the common electrode Y_2 is selected by the common electrode selection circuit 4 and a voltage which is not higher than "Vth1" is applied to the segment electrodes X_1 through X_m by means of the segment electrode drive circuit 3 to read the brightness data of the pixels in the 2nd row and *m* columns.

The above-mentioned operation is repeated to read the brightness data (i.e, image data) of the matrix of pixels in *n* rows and *m* columns as an electric signal.

Although the control light is irradiated from the side of the glass plate 29 in order to make the photoconductor 22 have a low resistance in the example described above, such a measure is not always required to be taken.

When the above measure is not taken, the electrostatic capacitance which generates the induction voltage at the common electrode Y is a synthetic electrostatic capacitance formed by successively connecting the electrostatic capacitance across the segment electrode X and the island electrode 23 with the electrostatic capacitance across the island electrode 23 and the common electrode Y. Therefore, the induction voltage generated at the common electrode Y depending on the alignment state of the liquid crystals 21 constituting each pixel exhibits a reduced variance in level and an increased irrelevant DC component voltage.

Because of a great voltage drop due to the dark resistance of the photoconductor 22, a voltage which is not lower than "Vth1" can be applied across the segment electrode X and the common electrode Y to allow the reduction of variance in level to be suppressed to some extent.

(4) Image display mode (in which an image is written into the image input device-integrated display unit by means of an electric signal)

The operation in the present mode is the same as in the image display mode of the conventional liquid crystal display.

Fig. 8 shows a schematic sectional view of the image input device-integrated display unit 1, where elements irrelevant to the image display mode are eliminated.

Illumination light is irradiated by the back light 11 from the side of the glass plate 29. Then the incident light strikes on the photoconductor 22 to make the photoconductor 22 have a low resistance, with which the island electrode 23 and the segment electrode X are made to have an approximately equal potential. Therefore, a voltage approximately equal to the voltage applied to the segment electrode X appears at the island electrode 23.

First, the common electrode Y_1 in the 1st row is selected by the common electrode drive circuit 2 to receive a specified voltage. In the above condition, a voltage corresponding to image data is applied to the segment electrode X_a by the segment electrode drive circuit 3 based on a display signal from the aforementioned display control circuit 6 (refer to Fig. 1). Consequently, an approximately equal voltage is applied to the island electrode 23_a, while a voltage approximately equal to the voltage across the segment electrode X_a and the common electrode Y_1 (the voltage referred to as the "display voltage" hereinafter) is applied to the liquid crystals 21 in the area of the island electrode 23_a.

Therefore, when the above-mentioned display voltage is not lower than "Vth1" and lower than "Vth2" as shown in Fig. 3, the liquid crystals 21 in the relevant pixel area are put into the focalconic state and dark data are written into the liquid crystals. In contrast to the above, when the display voltage is not lower than "Vth2", the liquid crystals 21 in the relevant pixel area are put into the homeotropic orientation and light data are written into the liquid crystals.

Then a voltage corresponding to image data is applied to the segment electrode X_b by the segment electrode drive circuit 3. Consequently, a voltage approximately equal to the display voltage is applied to the liquid crystals 21 in the area of the relevant island electrode 23_b, and light data or dark data are written into the relevant liquid crystals 21 according to the display voltage.

By repeating the above-mentioned operation, voltages corresponding to the image data are successively written into the segment electrodes X_1, X_2, ... X_m under the control of the segment electrode drive circuit 3, with which the image is written into the pixels in the 1st row and *m* columns of the aforementioned pixel matrix.

Then, the common electrode Y_2 in the 2nd row is selected by the common electrode drive circuit 2 to receive a specified voltage. In the above condition, voltages corresponding to the image data are successively applied to all the segment electrodes X_1, X_2, ... X_m by the segment electrode drive circuit 3, with which the image is written into the pixels in the 2nd row and *m* columns.

Subsequently, the above-mentioned operation is repeated to write the image into the matrix of pixels in *n* rows and *m* columns to display the image.

The above are the principle of operations in each of the image input mode, pen input mode, image read mode, and image display mode of the image input device-integrated display unit 1 employing phase transition type liquid crystals as the liquid crystals 21.

In the present embodiment as described above, phase transition type liquid crystals are interposed between the common electrode Y formed via the light-shielding film 25 on the glass plate 28 and the island electrode 23 of each pixel electrically connected via the photoconductor 22 to the segment electrode X formed on the glass plate 29 to constitute the image input device-integrated display unit 1.

In the image input mode, the phase transition type liquid crystals in all the pixels of the pixel matrix composed of the areas of intersections between a plurality of segment electrodes X and a plurality of common electrodes Y are put into the Grandjean state under the control of the display control circuit 6, image input control circuit 8, and back light control circuit 12. Subsequently, reflection light from the white area of the document 31 is made to strike on the photoconductor 22 to make the photoconductor 22 have a low resistance to thereby put the phase transition type liquid crystals of the pixels on which the reflection light strikes into the focalconic state.

Thus the optical image of the document is copied

into the pixel matrix.

In the pen input mode, the phase transition type liquid crystals in all the pixels of the pixel matrix are put into the Grandjean state under the control of the display control circuit 6, image input control circuit 8, and back light control circuit 12. Subsequently, reflection light of the light from the light source 41 of the input pen 10 is made to strike on the photoconductor 22 to make the photoconductor 22 have a low resistance to thereby put the phase transition type liquid crystals of the pixels at which the pen input took place into the focalconic state.

Thus the image is written into the above-mentioned pixel matrix by means of the input pen 10.

In the image read mode, the control light from the back light 11 is made to strike on the photoconductor 22 to make the photoconductor 22 have a low resistance to thereby scan the island electrodes 23 successively with a voltage such that it does not change the state of the phase transition type liquid crystals under the control of the image data detection control circuit 7 and the back light control circuit 12. In the above time, each common electrode Y is successively selected by the common electrode selection circuit 4 to detect the time series of the voltage induced at the common electrode Y by means of the image data detection circuit 9.

Thus the image data of each pixel constituting the aforementioned pixel matrix (i.e., the alignment state of the phase transition type liquid crystals) are taken out as an electric signal corresponding to the alignment state of the phase transition type liquid crystals pertinent to the pixel.

In the image display mode, voltages corresponding to the image data are applied to all the segment electrodes X_1 through X_m while successively selecting each common electrode Y under the control of the display control circuit 6 and the back light control circuit 12. In the above time, the control light from the back light 11 is made to strike on the photoconductor 22 to make the photoconductor 22 have a low resistance to thereby apply a voltage corresponding to the image data to the phase transition type liquid crystals of the relevant pixels constituting the pixel matrix, with which the alignment state of the phase transition type liquid crystals of the relevant pixels is put into an alignment state corresponding to the image data.

Thus an image corresponding to the image data is written into the above-mentioned pixel matrix to display the image.

Therefore, according to the image input device-integrated type display device employing the image input device-integrated display unit 1 of the present embodiment, the image display function, document optical image copying function, display image read function, and the pen input function can be provided by one device.

Second embodiment

Then the following describes the operation of the image input device-integrated display unit 1 employing a current/electric field effect type liquid crystals as the liquid crystals 21 in regard to each mode. The liquid crystals of the above type are n-type cholesteric liquid crystals, liquid crystals formed by mixing the n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals.

It is noted that the image input device-integrated display unit of the present embodiment has utterly the same construction as that of the image input device-integrated display unit 1 as shown in Fig. 2 except for the liquid crystals. Therefore, the following description is made with reference to Fig. 2.

Before explaining the operation, reference is first made to a change of the alignment state of the liquid crystals.

Figs. 9 (a) through 9 (d) schematically show a change of the state of the current/electric field effect type liquid crystals.

Referring to Fig. 9 (a), in the initial state, the helical axes of the cholesteric liquid crystal molecules are in the Grandjean state where the helical axes are aligned in a direction perpendicular to the electrode surfaces, when the current/electric field effect type liquid crystals (referred to merely as the "liquid crystals" in the present embodiment) are transparent.

Then referring to Fig. 9 (b), when a DC voltage or a low-frequency AC voltage is applied to the liquid crystals and the voltage is gradually increased, the negative ions incorporated into the liquid crystals move at a voltage which is not lower than a threshold voltage. With the above-mentioned operation, the helical axes aligned in a direction are disordered to be directed in irregular directions to be in the focalconic state. In the focalconic state, the liquid crystals are optically opaque.

The focalconic state is stored even when the electric field is removed as shown in Fig. 9 (c).

In order to erase the alignment state of the liquid crystals thus stored, a voltage having a high frequency (several kilohertz) at which no current effect is generated is applied to the liquid crystals as shown in Fig. 9 (d). With the above-mentioned operation, the liquid crystal molecules directed in irregular directions are aligned in a direction to be restored into the Grandjean state.

The above-mentioned liquid crystal molecules have an anisotropy of dielectric constant, and therefore the dielectric constant of the entire liquid crystal cell changes depending on the alignment state of the liquid crystal molecules.

(1) Image input mode

In a first step, the liquid crystals 21 are entirely

put into the transparent state (i.e., the aforementioned Grandjean state).

Control light is irradiated by the back light 11 from the side of the glass plate 29, and a voltage having a high frequency (several kilohertz) at which no current effect is generated is applied across the segment electrode X and the common electrode Y under the control of the display control circuit 6. In the above time, the voltage may be applied either successively or simultaneously. Consequently, the liquid crystals 21 are put into the Grandjean state to be entirely transparent, i.e., put into the initial state before the write operation.

In a second step, the reflection light from the document is copied into the liquid crystals 21.

The above-mentioned document is placed under the glass plate 29 with the document closely fit to the glass plate 29. Under the control of the image input control circuit 8, a DC voltage or a low-frequency AC voltage which is not lower than the threshold voltage at which the liquid crystals 21 are transformed into the focalconic state by the current effect is applied successively or simultaneously across each segment electrode X and each common electrode Y. Then by irradiating document illumination light by means of the back light 11 from the side of the glass plate 28, the light transmitted through the image input device-integrated display unit 1 is converged on the surface of the document by the micro lens 27.

In the case where the convergence light strikes on a white area of the document, the reflection light strikes on the photoconductor 22 to make the photoconductor 22 have a low resistance. Then a voltage approximately equal to the DC voltage or the low-frequency AC voltage which is not lower than the aforementioned threshold voltage applied across the segment electrode X and the common electrode Y is applied across the island electrode 23 and the common electrode Y (i.e., to the liquid crystals 21), with which the liquid crystals 21 are transformed from the Grandjean state where the liquid crystals are transparent to the focalconic state where the liquid crystals are turbid whitely.

In other words, the white area of the document is invertedly written into the liquid crystals 21 as a black area.

In contrast to the above, in the case where the convergence light strikes on a black area of the document, no reflection light strikes on the photoconductor 22 to allow the photoconductor 22 to remain having a high resistance. In the above time, by setting the dark resistance of the photoconductor 22 at a value such that it becomes higher than the resistance of the liquid crystals 21, a great voltage drop due to the photoconductor 22 results to apply almost no voltage across the island electrode 23 and the common electrode Y. Therefore, the liquid crystals 21 maintain the initial Grandjean state to be transparent.

In other words, the black area of the document is invertedly written into the liquid crystals 21 as a white area.

Thus the negative image of the document is written into the matrix of $n \times m$ pixels of the image input device-integrated display unit 1.

(2) Pen input mode

The liquid crystals 21 are put into the initial state in the same manner as in the aforementioned image input mode. Subsequently, under the control of the image input control circuit 8, a DC voltage or a low-frequency AC voltage which is not lower than the threshold voltage at which the liquid crystals 21 are transformed into the focalconic state is applied successively or simultaneously across each segment electrode X and each common electrode Y. It is noted that the principle of the pen input operation is the same as the principle of operation in the aforementioned image input mode.

When the pen touch switch 45 of the input pen 10 having a structure as shown in Fig. 6 is turned on, light is emitted from the light source 41. Then the light from the light source 41 is transmitted through the image input device-integrated display unit 1 and reflected on the white sheet placed under the glass plate 29 to be incident on the photoconductor 22.

Consequently, the resistance of the photoconductor 22 is reduced to make the electric potential at the island electrode 23 be approximately equal to the electric potential at the segment electrode X, and the DC voltage or the low-frequency AC voltage which is not lower than the aforementioned threshold voltage is applied to the liquid crystals 21 constituting the relevant pixel. Thus the liquid crystals 21 are transformed into the focalconic state (where the liquid crystals are turbid whitely).

Subsequently, when the input pen 10 is moved out of the relevant pixel area or the input pen 10 is put apart from the image input device-integrated display unit 1 to turn off the pen touch switch 45, no light is incident on the relevant pixel to make the resistance of the photoconductor 22 be the dark resistance. Consequently, a great voltage drop takes place at the photoconductor 22, with which the voltage applied to the liquid crystals 21 is made to be "0".

Thus the liquid crystals 21 in the relevant pixel area which are put into the focalconic state by the pen input maintains the focalconic state. In other words, dark data are written into the liquid crystals 21 in the relevant pixel area by the pen input.

By time-sharingly processing the above-mentioned pen input mode and the image read mode as described hereinafter, the coordinates of the pixel currently designated by the input pen 10 can be detected.

In order to erase the image data already written,

a voltage which has a high frequency (several kilohertz) not lower than the aforementioned threshold value is required to be applied across the segment electrode X and the common electrode Y to put the liquid crystals 21 of the pixels traced by the input pen 10 into the Grandjean state.

(3) Image read mode

Control light is irradiated by the back light 11 from the side of the glass plate 29 of the image input device-integrated display unit 1. Then the incident light strikes on the photoconductor 22 to make the photoconductor 22 have a low resistance.

In the above condition, pulses of a DC voltage or a low-frequency AC voltage not higher than the aforementioned threshold voltage is successively applied to each of the segment electrodes X_1, X_2, ... X_m by means of the segment electrode drive circuit 3 under the control of the aforementioned image data detection control circuit 7. In the above time, since the photoconductor 22 has a low resistance, the island electrode 23 is scanned by a pulse having a voltage approximately equal to the voltage applied to the segment electrode X. In the above case, the above-mentioned DC voltage or the low-frequency AC voltage not higher than the aforementioned threshold value is applied to the liquid crystals 21, and therefore the alignment state of the liquid crystals 21 does not change.

Consequently, a voltage is induced at the common electrode Y due to the pulse voltage applied to the island electrode 23 which is electrostatically coupled with the aforementioned common electrode Y. In the above case, the magnitude of the induction voltage corresponds to the electrostatic capacitance generated across the island electrode 23 and the common electrode Y. Since the distance between the island electrode 23 and the common electrode Y is constant, the electrostatic capacitance across the island electrode 23 and the common electrode Y varies according to the dielectric constant of the liquid crystals 21.

The dielectric constant of the liquid crystals 21 varies according to the alignment state of the liquid crystal molecules. The alignment state of the liquid crystal molecules determines the brightness condition of the data to be written.

Therefore, by detecting the voltage induced by selecting one common electrode Y while the segment electrodes X_1 through X_m are scanned once, the alignment state of the liquid crystals 21 of the pixels in the 1st row and *m* columns provided in the position of the common electrode Y (i.e., the brightness condition of the pixel) can be detected in time series.

Thus by scanning the segment electrodes X_1 through X_m by means of the segment electrode drive circuit 3 every time selecting successively each of the common electrode Y_1 through Y_n by means of the common electrode selection circuit 4, image data of the matrix of the pixels in *n* rows and *m* columns are read as an electric signal.

It is noted that the control light for making the photoconductor 22 have a low resistance is not always required to be irradiated in the above-mentioned image read mode.

(4) Image display mode

Illumination light is irradiated by the back light 11 from the side of the glass plate 29. Then the photoconductor 22 is made to have a low resistance to make the island electrode 23 have approximately equal electric potential as the electric potential at the segment electrode X.

In the above condition, each common electrodes Y is successively selected by the common electrode drive circuit 2 under the control of the display control circuit 6 to set the common electrode Y at a specified electric potential. Then all the segment electrodes X_1 through X_m are successively scanned by the segment electrode drive circuit 3 while a specified common electrode is selected to apply the aforementioned DC voltage (or the low-frequency AC voltage) or a high-frequency (several kilohertz) not lower than the threshold value to each of the segment electrodes X_1 through X_m according to the image data.

Consequently, the pixels relevant to the liquid crystals 21 to which the DC voltage (or the low-frequency AC voltage) not lower than the aforementioned threshold value is applied among the pixels constituting the aforementioned pixel matrix exhibit a dark display. Meanwhile, the pixels relevant to the liquid crystals 21 to which the high-frequency voltage is applied exhibit a light display. Thus an image corresponding to the aforementioned image data is displayed on the above-mentioned pixel matrix.

Third embodiment

Then the following describes the principle of operation of the image input device-integrated display unit 1 employing ferroelectric liquid crystals as the liquid crystals 21 in regard to each mode.

Fig. 10 is a sectional view showing the structure of an image input device-integrated type display unit 1 of the present embodiment taken along the common electrode Y, where the same components as those in Fig. 2 are denoted by the same numerals and no detailed description therefor is provided herein.

The above-mentioned ferroelectric liquid crystals are in either of only two stable states in the case where they are encapsulated in a cell having a thickness of several micrometers. The liquid crystals have the characteristic of storing either of the stable states in which they are.

In the above case, the above-mentioned two stable states include the state in which the ferroelectric liquid crystals are directed in one direction (assumed to be a direction A) and the state where the ferroelectric liquid crystals are directed in the other direction (assumed to be a direction B) in a plane in parallel with the aforementioned cell. When a polarization plate is placed with its polarization direction directed in a direction perpendicular to one (assumed to be the direction A) of the two directions, the ferroelectric liquid crystals of which molecules are directed in the direction (direction A) produce a transmission light having a low intensity. The ferroelectric liquid crystals of which molecules are directed in the other direction (direction B) produce a transmission light having a high intensity. It is noted that the two directions (direction A and direction B) are not always perpendicular to each other in the above case.

A transition between the above-mentioned two stable states can be effected only by changing the polarity of the voltage to be applied to the liquid crystals.

Referring to Fig. 10, there are included ferroelectric liquid crystals 51, a photoconductor 22, an island electrode 23, a segment electrode X, and a common electrode Y. It is noted that the segment electrode X, the common electrode Y, and the island electrode 23 are transparent electrodes made of ITO (indium tin oxide).

A polarizer 52 is formed on the common electrode Y on the photoconductor 22. The polarization direction of the polarizer 52 is in the same direction as that of the common electrode Y in the plane of the paper on which Fig. 10 is illustrated, the polarization direction indicated by an arrow "← →" as shown in Fig. 10.

The ferroelectric liquid crystals 51 exhibit two stable molecule alignments in a plane which is perpendicular to the plane of the paper and in parallel with the polarization direction of the polarizer 52. One of the alignments is a molecular alignment in a direction perpendicular to the polarization direction of the polarizer 52, the molecular alignment indicated by "•" as shown in Fig. 10. The other is the molecular alignment in a direction approximately in parallel with the polarizing element of the polarizer 52, the molecular alignment indicated by "← →".

Therefore, when the polarization direction of the polarizer 52 and the molecular alignment direction of the ferroelectric liquid crystals 51 are the combination of "← →" and "•", the polarization direction of the polarizer 52 and the alignment direction of the ferroelectric liquid crystals 51 are perpendicular to each other, and therefore a laminate of the polarizer 52 and the ferroelectric liquid crystals 51 allows less light to be transmitted therethrough. In contrast to the above, when the above-mentioned combination is of "← →" and "← →", the polarization direction of the polarizer 52 and the alignment direction of the ferroelectric liquid crystals 51 are approximately in parallel with each other, and therefore the laminate of the polarizer 52 and the ferroelectric liquid crystals 51 allows more light to be transmitted therethrough.

The two alignment directions of "← →" and "•" of the ferroelectric liquid crystals 51 can be controlled by inverting the polarity of the voltage applied across the common electrode Y and the island electrode 23. It is assumed in the present embodiment that the alignment direction of the ferroelectric liquid crystals 51 is "•" when the common electrode Y is in the negative polarity and the island electrode 23 is in the positive polarity, and conversely the alignment direction of the ferroelectric liquid crystals 51 is "← →" when the common electrode Y is in the positive polarity and the island electrode 23 is in the negative polarity.

(1) Image input mode

Figs. 11 (a) through 11 (d) show the operation of the image input device-integrated display unit 1 in the image input mode.

In a first step, the alignment direction of the entire ferroelectric liquid crystals 51 is put in the state of "•" as shown in Fig. 11 (a).

Control light is irradiated on the entire surface of the liquid crystals by the back light 11 from the side of the glass plate 29 to apply a negative voltage to the common electrode Y and a positive voltage to the segment electrode X from the power source 30 under the control of the display control circuit 6. In the above case, the voltages may be applied either successively or simultaneously. Consequently, the photoconductor 22 on which the control light strikes is made to have a low resistance, with which the island electrode 23 and the segment electrode X are made to have an equal voltage, while the alignment direction of the ferroelectric liquid crystals 51 is made to be entirely "•", i.e., in the initial state before the write operation.

In a second step, reflection light from a document is copied into the ferroelectric liquid crystals 51.

In a manner as shown in Fig. 11 (b), the document 31 is placed under the glass plate 29 with the document closely fit to the glass plate 29. Under the control of the image input control circuit 8, a positive voltage is applied to the common electrode Y and a negative voltage is applied to the segment electrode X from the power source 30. In the above case, the voltages may be applied either successively or simultaneously. Then polarized illumination light having a polarization direction of "•" is irradiated on the entire surface of the liquid crystals from the side of the glass plate 28.

Consequently, the polarization direction of the polarized illumination light is perpendicular to the polarization direction of the polarizer 52, and therefore the polarized illumination light does not enter into a

portion directly below the polarizer 52. In other words, the polarized illumination light from above does not reach the polarizer 52. Meanwhile, the alignment direction of the ferroelectric liquid crystals 51 is the same as the polarization direction of the polarized illumination light. Therefore, the polarized illumination light which enters from the area of the transparent insulator 26 except for the polarizer 52 and is transmitted through the common electrode Y to reach the ferroelectric liquid crystals 51 is transmitted through the ferroelectric liquid crystals 51. The polarized illumination light is further transmitted through the island electrode 23 and the segment electrode X to be converged on the surface of the document by the micro lens 27.

In the case where the convergence light strikes on a white area of the document 31, reflection light strikes on the photoconductor 22 to make the photoconductor 22 have a low resistance. Then the electric potential at the island electrode 23 is made to be approximately equal to the electric potential at the segment electrode X to apply the positive voltage to the common electrode Y and the negative voltage to the island electrode 23. Consequently, the alignment direction of the ferroelectric liquid crystals 51 changes from the state of "•" to the state of "← →" as shown in Fig. 11 (c).

In other words, the white area of the document 31 is written into the ferroelectric liquid crystals 51 as the alignment state of "← →".

In contrast to the above, in the case where the convergence light strikes on a black area of the document 31, no reflected light strikes on the photoconductor 22 as shown in Fig. 11 (d), and therefore the photoconductor 22 remains having a high resistance (dark resistance). In the above case, by making the dark resistance of the photoconductor 22 have a resistance higher than the resistance of the ferroelectric liquid crystals 51, a great voltage drop due to the photoconductor 22 results to apply almost no voltage across the island electrode 23 and the common electrode Y. Therefore, the alignment direction of the ferroelectric liquid crystals 51 is maintained in the state of "•".

In other words, the black area of the document 31 is written into the ferroelectric liquid crystals 51 as the alignment state of "•".

Thus the optical image of the document 31 where the two alignment directions of the ferroelectric liquid crystals 51 exist mixedly is written into the matrix of $n \times m$ pixels of the image input device-integrated display unit 1 and then temporarily stored. Therefore, in viewing the image copied into the above-mentioned pixel matrix, a positive image display results when the polarization direction of the display illumination light irradiated from the side of the glass plate 29 is "← →", while a negative image display results when the polarization direction is "•".

(2) Pen input mode

Figs. 12 (a) through 12 (c) show the operation of the image input device-integrated display unit 1 in the pen input mode.

In a first step, the alignment direction of the entire ferroelectric liquid crystals 51 is put in the state of "← →" as shown in Fig. 12 (a).

Control light is irradiated on the entire surface of the liquid crystals by the back light 11 from the side of the glass plate 29 to apply a positive voltage to the common electrode Y and a negative voltage to the segment electrode X from the power source 30 under the control of the display control circuit 6. In the above case, the voltages may be applied either successively or simultaneously. Consequently, the photoconductor 22 on which the control light strikes is made to have a low resistance, with which the island electrode 23 and the segment electrode X are made to have an equal voltage, while the alignment direction of the ferroelectric liquid crystals 51 is made to be entirely "← →", i.e., in the initial state before the write operation.

In a second step, an image is written on the pixel matrix by means of the input pen 10.

Under the control of the image input control circuit 8, a negative voltage is applied to the common electrode Y and a positive voltage is applied to the segment electrode X from the power source 30 as shown in Fig. 12 (b). In the above case, the voltages may be applied either successively or simultaneously.

In the above condition, the tip of the input pen 10 having a structure as shown in Fig. 6 is pressed against a pen input position on the image input device-integrated display unit 1. Then the pen touch switch 45 is turned on to emit light from the light source 41. The light from the light source 41 is circularly polarized light, and therefore the light is transmitted through the polarizer 52 to directly strike on the photoconductor 22. Consequently, the photoconductor 22 is made to have a low resistance to make the island electrode 23 and the segment electrode X have an equal electric potential, with which the alignment direction of the ferroelectric liquid crystals 51 is transformed from the initial state of "← →" to the state of "•".

Subsequently, when the input pen 10 is moved out of the relevant pixel area or the input pen 10 is put apart from the image input device-integrated display unit 1 to turn off the pen touch switch 45, no light is incident on the relevant pixel to make the resistance of the photoconductor 22 be the dark resistance. Consequently, a great voltage drop takes place at the photoconductor 22, with which the voltage applied to the ferroelectric liquid crystals 51 is made to substantially be "0".

Thus the ferroelectric liquid crystals 51 of which

alignment direction is "•" by the pen input maintains their alignment state. In other words, image data are written and stored into the ferroelectric liquid crystals 51 in the relevant pixel area by the pen input. It is noted that the island electrode 23 is charged with positive electric charges in the above case as shown in Fig. 12 (c).

In contrast to the above, the ferroelectric liquid crystals 51 in the pixel area where no pen input took place maintain the initial state of "← →", while the island electrode 23 is not charged with electric charges.

By time-sharingly processing the above-mentioned pen input mode and the image read mode as described hereinafter, the coordinates of the pixel at which the input pen 10 is designating can be detected.

In order to erase the image already written, a negative voltage is applied to the segment electrode X and a positive voltage is applied to the common electrode Y to change the alignment direction of the ferroelectric liquid crystals 51 in the pixel area which was traced by the input pen 10 into the state of "← →".

In the pen input mode of the aforementioned first and second embodiments, an image is written into the liquid crystals by means of reflection light from the input pen 10, and therefore a white- sheet is necessary as a reflective object. However, in the pen input mode of the present embodiment, an image is directly written into the ferroelectric liquid crystals 51 by means of light from the input pen 10, and therefore no white sheet is necessary as a reflective object.

(3) Document image read mode

The document image read mode is the mode for reading brightness data of a document as an electric signal.

Figs. 13 (a) through 13 (c) show the operation of the image input device-integrated display unit 1 in the document image read mode.

In a first step, the alignment direction of the entire ferroelectric liquid crystals 51 is put into the initial state of "← →" as shown in Fig. 13 (a).

Control light is irradiated on the entire surface of the liquid crystals by the back light 11 from the side of the glass plate 29. Under the control of the display control circuit 6, a positive voltage is applied to the common electrode Y and a negative voltage is applied to the segment electrode X from the power source 30. Consequently, the island electrode 23 and the segment electrode X are made to have an equal voltage, with which the alignment direction of the entire ferroelectric liquid crystals 51 is put into the state of "← →". Subsequently when irradiation of the control light is stopped, the island electrode 23 is charged with negative electric charges. The above-mentioned state is the initial state.

In a second step, reflection light from the document is copied into the ferroelectric liquid crystals 51.

In a manner as shown in Fig. 13 (b), polarized illumination light having a polarization direction of "•" perpendicular to the polarization direction of "← →" of the polarizer 52 is irradiated from the side of the glass plate 28. Meanwhile, a document 31 is placed under the glass plate 29 with the document closely fit to the glass plate 29. Under the control of the image input control circuit 8, a positive voltage is applied to the segment electrode X and a negative voltage is applied to the common electrode Y from the power source 30. It is noted that the voltage applied to the ferroelectric liquid crystals 51 is a voltage which is lower than such a threshold voltage that it does not change the alignment direction.

Since the polarization direction of "← →" of the polarizer 52 and the polarization direction of "•" of the polarized illumination light are perpendicular to each other, the photoconductor 22 is not directly illuminated the polarized illumination light. Besides, the two possible alignment directions- of the ferroelectric liquid crystals 51 are not perfectly perpendicular to each other for the reason as described above. Therefore, the polarization direction of the polarized illumination light and the alignment direction of the ferroelectric liquid crystals 51 are not perfectly perpendicular to each other, which results in a small quantity of light transmitted from the ferroelectric liquid crystals 51. The transmission light is used to illuminate the document 31.

When there is reflection light from the document 31, the resistance of the photoconductor 22 is reduced. In the above case, a positive voltage which is not higher than the threshold value is applied to the segment electrode X. Therefore, the negative electric charges charged at the island electrode 23 leak by way of the photoconductor 22. Consequently, the quantity of negative charges at the island electrode 23 is reduced. When there is no reflection light from the document 31, the resistance of the photoconductor 22 keeps the dark resistance. Therefore, the island electrode 23 is still charged with the negative electric charges built up in the initial state.

Thus the monochrome data of the aforementioned document 31 are copied as- data of electric charges at the island electrode 23.

In either of the above-mentioned cases, the alignment direction of the ferroelectric liquid crystals 51 does not change.

In a third step, the image data copied into the island electrode 23 are converted into an electric signal.

In a manner as shown in Fig. 13 (c), control light having a polarization direction of "← →" in parallel with the polarization direction of "← →" of the aforementioned polarizer 52 is irradiated from the side of the glass plate 28. Under the control of the image

data detection control circuit 7, a negative voltage is applied to each segment electrode X and a positive voltage is applied to each common electrode Y from the power source 30.

Then a load resistor is inserted in a portion of the electric circuit composed of the aforementioned power source 30, common electrode Y, and segment electrode X.

In the pixel where the quantity of electric charges at the island electrode 23 is reduced by the reflection light from the document 31 in the above-mentioned second step, negative charges are supplemented to the island electrode 23 from the segment electrode X to which the negative voltage is applied. In the above case, a current flows through the aforementioned electric circuit, and therefore an electric potential difference takes place across the terminals of the load resistor.

In contrast to the above, in the pixel where the quantity of the electric charges at the island electrode 23 is not reduced because of no reflection light from the document 31, the negative charges are not supplemented to the island electrode 23 from the segment electrode X, and therefore no electric potential difference takes place across the terminals of the load resistor.

In a third step, the above-mentioned load resistor is practically connected to the segment electrode X, and the aforementioned control light having the polarization direction of "$\leftarrow \rightarrow$" is irradiated on each common electrode Y one by one. Then the control light is irradiated successively onto the common electrode Y_1 through the common electrode Y_n to scan the common electrode Y. By successively detecting the electric potential differences across the terminals of the load resistor connected to each of the segment electrodes X_1 through X_m when the control light is irradiated on a certain common electrode Y, the charge conditions of the island electrode 23 in (m) pixels provided at the position of the common electrode Y (i.e., the presence or absence of reflection light from the document 31, which is equal to the brightness condition of the document 31) can be read as a time series of an electric signal.

Fig. 14 shows the concept of the operation of the image input device-integrated display unit 1 in the document image read mode. The electric circuit composed of the aforementioned power source 30, common electrode Y, and segment electrode X can be expressed by an equivalent circuit as shown in Fig. 14 (a).

In more detail, a capacitor 55 is the electrostatic capacitance across the above-mentioned common electrode Y and the island electrode 23. A switch 56 is the photoconductor 22 which is made to have a low resistance (i.e., "on" condition) when it receives light to make the electric potential at the island electrode 23 equal to the electric potential at the segment electrode X. A power source 57 is the aforementioned power source 30.

First, control light is temporarily irradiated on the above-mentioned switch 56 to turn on the switch 56 and thereby charge the capacitor 55 with electric charges (aforementioned first step).

Then, as shown in Fig. 14 (b), the electric charges in the capacitor 55 is made to leak by removing the power source 57 (making the voltage applied to the ferroelectric liquid crystals 51 from the power source 30 be not higher than the threshold voltage) and thereby turning on the switch 56. In the above case, turning-on and turning-off operations of the switch 56 are controlled by the reflection light from the document 31 (aforementioned second step).

Then, as shown in Fig. 14 (c), the aforementioned power source 57 is inserted again and a load resistor R_L is inserted in between the switch 56 and the power source 57. The switch 56 is turned on to supplement the electric charges leaked from the capacitor 55 by means of the power source 57. Then, in a capacitor 55 from which the electric charges have leaked, a current flows to supplement the leak electric charges to generate an electric potential difference across the terminals of the load resistor R_L. In contrast to the above, in a capacitor 55 from which no electric charges have leaked, no current flows to generate no electric potential difference across the terminals of the load resistor R_L (aforementioned third step).

Therefore, by detecting the electric potential difference across the terminals of the above-mentioned load resistor R_L, the optical image of the document 31 can be read as an electric signal.

It is noted that the turning-on and turning-off of the switch 56 is controlled by the control light irradiated on each common electrode Y one by one.

(4) Image read mode

The operation of the image input device-integrated display unit 1 in the image read mode is basically the same as in the aforementioned document image read mode.

Fig. 15 (a) shows the condition of the image input device-integrated display unit 1 relevant to the pixel immediately after image data are written into the matrix of $n \times m$ pixels by the input pen 10 in the aforementioned pen input mode. The condition shown in Fig. 15 (a) is the same as the condition shown in Fig. 12 (c), where the island electrode 23 is charged with positive electric charges.

Then, as shown in Fig. 15 (b), a linear control light is irradiated on each common electrode Y one by one from the side of the glass plate 29 of the image input device-integrated display unit 1 to scan the common electrodes Y_1 through Y_m. Under the control of the image data detection control circuit 7, a negative voltage is applied to each segment electrode X and a

positive voltage is applied to each common electrode Y from the power source 30. In the above case, each of the voltages applied to the ferroelectric liquid crystals 51 is a voltage which is not higher than the threshold value at which the alignment direction of the ferroelectric liquid crystals 51 is not changed.

Then a load resistor is inserted in a portion of the electric circuit composed of the aforementioned power source 30, common electrode Y, and segment electrode X.

As described above, the island electrode 23 relevant to the pixel at which the pen input took place is charged with positive electric charges. Therefore, control light is irradiated on the photoconductor 22 to make the island electrode 23 and the segment electrode X have an equal electric potential. Then a negative voltage is applied to the segment electrode X and a positive voltage is applied to the common electrode Y, with which a current flows through the aforementioned electric circuit to produce an electric potential difference across the terminals of the aforementioned load resistor.

In contrast to the above, the island electrode 23 relevant to the pixel at which no pen input took place is not charged with positive electric charges. Therefore, no current flows through the aforementioned electric circuit to produce no electric potential difference across the terminals of the aforementioned load resistor.

Thus by detecting the electric potential difference across the terminals of the aforementioned load resistor, the image data written into the pixel matrix of the image input device-integrated display unit 1 by the input pen 10 can be read as an electric signal.

(5) Image display mode

The image display mode is the mode in which image data are written into the pixel matrix of the image input device-integrated display unit 1 according to an electric signal. It is noted that the principle of image display operation by means of the image input device-integrated display unit 1 is the same as the principle of image display operation of the conventional simple matrix type liquid crystal display.

In a manner as shown in Fig. 16 (a), control light having a polarization direction of "← →" is irradiated by the back light 11 from the side of the glass plate 29. Consequently, the photoconductor 22 on which the illumination light strikes is made to have a low resistance to make the island electrode 23 and the segment electrode X have an equal electric potential. In the above condition, a negative voltage is applied to each segment electrode X and a positive voltage is applied to each common electrode Y from the power source 30 under the control of the display control circuit 6. In the above time, a voltage which is not lower than a threshold value at which the alignment direction of the ferroelectric liquid crystals 51 is changed is applied to the ferroelectric liquid crystals 51. Consequently, the alignment direction of the ferroelectric liquid crystals 51 is made to be "← →".

In due course, the alignment direction of the ferroelectric liquid crystals 51 and the polarization direction of the illumination light are put in parallel with each other, with which the illumination light irradiated from the side of the glass plate 29 is transmitted through the image input device-integrated display unit 1.

Then each common electrode Y is successively selected by the common electrode drive circuit 2 to apply a specified negative voltage from the power source 30. While a certain common electrode is selected, a positive voltage is applied to all the segment electrodes X_1 through X_m by means of the segment electrode drive circuit 3. In the above time, a voltage which is not lower than the threshold value at which the alignment direction of the ferroelectric liquid crystals 51 is changed is applied to the segment electrode X relevant to the pixel at which an image is displayed according to image data. Meanwhile, a voltage which is lower than the above-mentioned threshold value is applied to the segment electrode X relevant to the pixel at which no image is displayed.

Consequently, as shown in Fig. 16 (b), the alignment direction of the ferroelectric liquid crystals 51 relevant to the pixel at which an image is displayed among the pixels constituting the aforementioned pixel matrix becomes "•" to be perpendicular to the polarization direction of "← →" of the illumination light. Therefore, the pixel at which an image is displayed exhibits a dark display.

Meanwhile, the alignment direction of the ferroelectric liquid crystals 51 relevant to the pixel at which no image is displayed remains "← →" to be approximately in parallel with the polarization direction of "← →" of the illumination light. Therefore, the pixel at which no image is displayed exhibits a light display.

In the above case, by making the polarization direction of the illumination light equal to the polarization direction of the polarizer 52, the polarizer 52 is prevented from being displayed as a black dot.

It is noted that a negative image where the light portion and the dark portion are inverted can be displayed by making the polarization direction of the illumination light be "•" perpendicular to the polarization direction of the polarizer 52. The negative image can be also displayed by inverting the polarities of the voltages applied to the segment electrode X and the common electrode Y with the polarization direction of the illumination light kept intact.

As described above, a positive/negative inversion can be achieved through a simple process in the case of the ferroelectric liquid crystals 51.

Fourth embodiment

The micro lens 27 provided at the image input device-integrated display unit 1 in each of the aforementioned embodiments has a function of condensing the illumination light on the surface of the document and a function of preventing the cross-talk of the reflection light from the document in the image input mode. However, there is the drawback that the illumination light cannot be effectively used in the image display mode.

In order to solve the above-mentioned drawback, a plate-shaped optical fiber array 61 as shown in Fig. 17 is used. It is noted that the plate-shaped optical fiber array 61 is used in place of the glass plate 29 of the aforementioned image input device-integrated display unit 1.

The above-mentioned plate-shaped optical fiber array 61 is substantially composed of cylindrical optical fibers 62 each having a certain length and a grating-shaped partition 63 for partitioning a plurality of optical fibers 62 two-dimensionally arranged in parallel with each other to hold the optical fibers 62 as formed in a plate shape where the lengthwise direction of the optical fibers extends in the thickness direction of the optical fiber array 61. Each area partitioned by the above-mentioned partition 63 is a pixel area.

The above-mentioned partition 63 is made of an opaque material in order to prevent the cross-talk between the pixels. In order to reduce the loss of light, the projection area of the partition 63 is made to be as small as possible.

As shown in Fig. 17, a difference-in-level 64 is provided between one end surface of the optical fibers 62 and an upper surface of the partition 63 at the upper in Fig. 17 (the upper surface referred to as the "surface A" hereinafter). On the other hand, the other end surface of the optical fibers 62 and a lower surface of the partition 63 are in an identical plane at the lower in Fig. 17 (the plane referred to as the "surface B" hereinafter). The segment electrode X, the transparent insulator 24, and so forth are laminated on the surface B.

The plate-shaped optical fiber array 61 having the above-mentioned structure functions as follows in the image input mode.

In the image input mode, a document is placed on the surface A (practically the surface A of the plate-shaped optical fiber array 61 is placed on the document). In the above case, since the difference-in-level 64 is provided between the end surface of the optical fibers 62 and the upper surface of the partition 63, there is a gap between the end surface of the optical fibers 62 and the surface of the document. By taking advantage of the gap, illumination light is transmitted from the surface B to the surface A by way of the optical fibers 62 positioned at the periphery of each pixel, while reflection light from the document is transmitted from the surface A to the surface B by way of the optical fibers 62 positioned at the center of each pixel.

As described above, the above-mentioned plate-shaped optical fiber array 61 has an ability of condensing illumination light inferior to the same function of the micro lens 27 in the image input mode, however, it has a sufficient cross-talk preventing function. There is almost no loss of illumination light irradiated from the surface A in the image display mode.

Fifth embodiment

There are three types of lights composed of display illumination light, document illumination light, and control light as light irradiated onto the image input device-integrated display unit 1. It is very effective for compacting the image input device-integrated type display device that one light source can concurrently serve as the above-mentioned three light sources. In view of the above, the image input device-integrated type display device of the present embodiment is provided with a back light 11 which concurrently serves as the above-mentioned three light sources.

One side portion of the image input device-integrated display unit 1 constituting the above-mentioned image input device-integrated type display device and one side portion of the back light 11 are connected together mutually pivotally around a pivot portion 65 as shown in Fig. 18 (a). The back light 11 is designed to be able to irradiate light outwardly from its both surfaces 11a and 11b.

With the above-mentioned arrangement, by turning the back light 11 by approximately 360° in angle around the pivot portion 65, the back light 11 can irradiate light either on a display surface la (on the side of the glass plate 28) or a reflection surface 1b (on the side of the glass plate 29) of the image input device-integrated display unit 1.

For instance, in the initial state of the aforementioned image input mode and the pen input mode, image read mode, or image display mode, the image input device-integrated display unit 1 and the back light 11 are in a relation in position as shown in Fig. 18 (b). Then the illumination light from the surface 11a of the back light 11 is irradiated on the reflection surface lb of the image input device-integrated display unit 1. In the above case, the light from the surface 11b of the back light 11 is not necessary, and therefore a reflection plate is arranged on the side of the surface 11b to make the light from the back light 11 be effectively irradiated on the image input device-integrated display unit 1.

Then in the aforementioned image input mode or the document image read mode of the third embodiment employing ferroelectric liquid crystals, the back

light 11 is turned by approximately 360° in angle around the pivot portion 65 from the position as shown in Fig. 18 (b) to put the image input device-integrated display unit 1 and the back light 11 in a relation in position as shown in Fig. 18 (c). Meanwhile, a document 31 is placed under the reflection surface lb of the image input device-integrated display unit 1. Thus the document illumination light from the surface 11b of the back light 11 is irradiated on the image display area la of the image input device-integrated display unit 1.

In the above case, the light from the surface lla of the back light 11 is not necessary, and therefore a reflection plate is arranged on the side of the surface 11a.

By making one back light 11 concurrently serve as the three types of display illumination light source, document illumination light source, and control light source in a manner as described above, the image input device-integrated type display device can be entirely formed very compactly.

As is evident from the above description, the image input device-integrated type display device controls the image input control circuit, document illumination light source, and control light source by means of a control circuit in the image input mode to drive the segment electrode and the common electrode by means of the segment electrode drive circuit and the common electrode drive circuit based on an image input signal from the above-mentioned image input control circuit, and controls the turning-on and turning-off of a voltage applied to the liquid crystals of the above-mentioned display unit by means of the light from the above-mentioned light sources to copy the optical image of a document into the pixel matrix of the above-mentioned display unit. In the image read mode, the display device controls the image read control circuit, image data detection circuit, and the control light source by means of the control circuit to drive the segment electrode and the common electrode by means of the segment electrode drive circuit and the common electrode drive circuit based on an image read signal from the aforementioned image read control circuit, and turns on the voltage applied to the liquid crystals of the above-mentioned display unit by means of the control light from the above-mentioned control light source to read the image data written in the above-mentioned pixel matrix as an electric signal by means of the above-mentioned image data detection circuit. In the image display mode, the display device controls the display control circuit and the display illumination light source by means of the control circuit to drive the segment electrode and the common electrode by means of the segment electrode drive circuit and the common electrode drive circuit based on the display signal from the above-mentioned display control circuit, and turns on the voltage applied to the liquid crystals of the above-mentioned display unit by means of the display illumination light from the display illumination light source to display an image corresponding to the above-mentioned display signal on the above-mentioned pixel matrix. With the above-mentioned arrangement, the display and copy operations of the optical image of the document on the pixel matrix of the above-mentioned display unit can be achieved under the control of the control circuit.

Therefore, according to the present invention, a compact integrated image input device-integrated type display device concurrently having an image display function and a document image input function can be provided.

According to an embodiment, there are employed the phase transition type liquid crystals as the above-mentioned liquid crystals. With the above-mentioned arrangement, the change of state of the liquid crystals according to the optical image of the document in the aforementioned image input mode or the change of state of the liquid crystals according to the display signal in the aforementioned image display mode can be achieved by the change of state between the Grandjean state and the focalconic state of the phase transition type liquid crystals. Furthermore, the read of the electric signal according to the image data in the aforementioned image read mode can be achieved, when a pulse is applied to one electrode of the electrodes interposing therebetween the above-mentioned phase transition type liquid crystals, by detecting the voltage signal induced at the other electrode.

Therefore, according to the present invention, a compact integrated image input device-integrated type display device concurrently having an image display function and a document image input function can be easily achieved.

According to an embodiment, there are employed n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals as the aforementioned liquid crystals. With the above-mentioned arrangement, the change of state of the liquid crystals according to the optical image of the document in the aforementioned image input mode or the change of state of the liquid crystals according to the display signal in the aforementioned image display mode can be achieved by the change of state between the Grandjean state and the focalconic state of the n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals. Furthermore, the read of the electric signal according to the image data in the aforementioned image read mode can be achieved, when a pulse is applied to one electrode of electrodes interposing therebetween the above-mentioned n-type cholesteric liquid crystals, liquid crystals formed

by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals, by detecting the voltage signal induced at the other electrode.

Therefore, according to the embodiment, a compact integrated image input device-integrated type display device concurrently having an image display function and a document image input function can be easily achieved.

According to the image input device-integrated type display device, there is provided a polarizer for controlling the polarization direction of only the light which enters from the side of the electrode which is one of the segment electrode and the common electrode of the display unit and is not electrically connected to the photoconductor before the light reaches the above-mentioned photoconductor. With the above-mentioned arrangement, the resistance of the photoconductor is controlled by the incident light from the above-mentioned electrode which is not electrically connected to the photoconductor by a combination of the polarization direction of the light which enters from the side of the above-mentioned electrode which is not electrically connected to the photoconductor and the polarizing element of the aforementioned polarizer, with which the turning-on and turning-off of the voltage applied to the liquid crystals can be controlled.

Therefore, an improved operability can be achieved in the image display operation and the document image input operation in the compact integrated image input device-integrated type display device concurrently having an image display function and a document image input function.

According to an embodiment, there are employed ferroelectric liquid crystals as the liquid crystals for use in a display unit having the aforementioned polarizer. With the above-mentioned arrangement, the change of state of the liquid crystals according to the optical image of the document in the aforementioned image input mode or the change of state of the liquid crystals according to the display signal in the aforementioned image display mode can be achieved by the change of the alignment direction of the above-mentioned ferroelectric liquid crystals.

Therefore, according to the embodiment, there can be easily achieved an image input device-integrated type display device which can control the turning-on and turning-off of the voltage applied to the liquid crystals by the incident light from the electrode which is one of the aforementioned segment electrode and the common electrode and is not electrically connected to the photoconductor.

According to an embodiment, the aforementioned image data detection circuit in the image input device-integrated type display device in which the aforementioned ferroelectric liquid crystals are inserted is designed to detect the quantity of electric charges charged according to image data at the island electrode in the aforementioned display unit. Meanwhile, the aforementioned control light source is designed to be able to scan one by one each electrode which is one of the segment electrode and the common electrode and is not electrically connected to the photoconductor. Furthermore, the control circuit is designed to detect the quantity of electric charges charged at the island electrode of the pixel relevant to one segment electrode or the common electrode selected by being irradiated by light from the aforementioned control light source in the image read mode to read the image data written in the above-mentioned pixel matrix as an electric signal. With the above-mentioned arrangement, the image data of the pixel matrix of the display unit employing the aforementioned ferroelectric liquid crystals can be easily read as an electric signal.

According to an embodiment, there is provided an input pen which emits light from a light source through its tip end. Meanwhile, the control circuit is designed to control the aforementioned image input control circuit and the control light source in the pen input mode to put the pixel matrix of the aforementioned display unit into the initial state and then drive the segment electrode and the common electrode by means of the segment electrode drive circuit and the common electrode drive circuit according to the aforementioned image input signal while turning on the voltage applied to the liquid crystals of the aforementioned display unit by means of the light from the above-mentioned input pen to change the alignment direction of the liquid crystals of the relevant pixel of the aforementioned pixel matrix. With the above-mentioned arrangement, an image can be input to the pixel matrix of the above-mentioned display unit by means of the above-mentioned input pen.

Therefore, according to the embodiment, a compact integrated image input device-integrated type display device concurrently having an image display function, a document image input function, and a pen input function can be provided.

According to an embodiment, there is provided a micro lens on one of the two transparent substrates of the aforementioned display unit. With the above-mentioned arrangement, light which enters from the side of the transparent substrate at which the micro lens is not provided, and is irradiated on the above-mentioned display unit can be converged.

In more detail, according to the embodiment, a sufficient quantity of light can be irradiated on the aforementioned photoconductor even when the document illumination light or the light emitted from the input pen is reduced at the time when it is reflected, for example, in the aforementioned image input mode or the pen input mode. With the above-mentioned arrangement, the brightness data of the document and the position data of the input pen can

be accurately written into the aforementioned pixel matrix.

According to an embodiment, at least one of the transparent substrates of the aforementioned display unit is constructed so that optical fibers each having a specified length are arranged two-dimensionally to constitute a plate-shaped optical fiber array of which axial direction is in the thickness direction of the optical fiber array. With the above-mentioned arrangement, the light which enters from the side of the optical fiber array travels through the above-mentioned optical fibers of the corresponding pixel in the axial direction of the optical fibers.

Therefore, according to the embodiment, an image input device-integrated type display device capable of efficiently executing the operation of each of the aforementioned modes without cross-talk between pixels constituting the pixel matrix of the above-mentioned display unit nor loss in quantity of light.

According to an embodiment, the aforementioned display illumination light source, document illumination light source, and control light source are provided by one plate-shaped light source, and a side portion of the plate-shaped light source is pivotally mounted to a side portion of the aforementioned display unit. With the above-mentioned arrangement, the above-mentioned display unit can be illuminated by the above-mentioned one plate-shaped light source from the front side or the back side of the display unit at need.

Therefore, according to the embodiment, the display illumination light source, document illumination light source, and control light source can be concurrently served by only one plate-shaped light source to allow an integrated image input device-integrated type display device concurrently having at least an image display function and a document image input function to be further compacted.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. An image input device-integrated type display device comprising:

a display unit (1) having a plurality of transparent segment electrodes (X) arranged in parallel with each other on a transparent substrate (29); a plurality of transparent common electrodes (Y) arranged in parallel with each other on another transparent substrate, said common electrodes (Y) being perpendicular to said segment electrodes (X), a photoconductor (22) electrically connected to either the segment electrode (X) or the common electrode (Y) and arranged in a pixel composed of an area of intersection between the segment electrode (X) and the common electrode (Y), a transparent island electrode (23) electrically connected to the photoconductor (22) and arranged in between the segment electrode (X) and the common electrode (Y) relevant to the pixel, liquid crystals (21) interposed between the island electrode (23) and an electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22), and a light shielding film (25) for shielding only light applying on the side of the electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22) so that the light does not reach the photoconductor (22);

a display illumination light source (11) which radiates display illumination light in displaying an image on a pixel matrix composed of areas of intersections between the plural segment electrodes (X) and the plural common electrodes (Y) of the display unit (1);

a document illumination light source (11) which radiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit (1);

a control light source (11) which radiates control light for optically controlling turning-on and turning-off of a voltage to be applied to liquid crystals (21) of the display unit (1);

a display control circuit (6) which generates a display signal for displaying an image on the pixel matrix of the display unit (1);

an image input control circuit (8) which generates an image input signal for copying an optical image of the document into the pixel matrix of the display unit (1);

an image read control circuit (7) which generates an image read signal for reading image data written in the liquid crystals (21) of each pixel constituting the pixel matrix of the display unit (1) in the form of an electric signal;

a segment electrode driving circuit (3) which drives the segment electrode (X) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from the image read control circuit (7);

a common electrode driving circuit (2) which drives the common electrode (Y) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from

the image read control circuit (7);

an image data detection circuit (9) which detects the image data written in the pixel matrix of the display unit (1) in the form of an electric signal; and

a control circuit (13) which copies the optical image of the document into the pixel matrix by controlling the image input control circuit (8), the document illumination light source (11), and the control light source (11) in an image input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the image read control circuit (7), the image data detection circuit (9), and the control light source (11) in an image read mode, and displays an image on the pixel matrix by controlling the display control circuit (6) and the display illumination light source (11) in an image display mode.

2. An image input device-integrated type display device as claimed in Claim 1, wherein

phase transition type liquid crystals (21) having a storage function are used as the liquid crystals (21).

3. An image input device-integrated type display device as claimed in Claim 1, wherein

n-type cholesteric liquid crystals, liquid crystals formed by mixing n-type cholesteric liquid crystals with n-type nematic liquid crystals, or smectic-A liquid crystals having a storage function are used as the liquid crystals (21).

4. An image input device-integrated type display device comprising:

a display unit (1) having a plurality of transparent segment electrodes (X) arranged in parallel with each other on a transparent substrate (29); a plurality of transparent common electrodes (Y) arranged in parallel with each other on another transparent substrate (28), said common electrodes (Y) being perpendicular to said segment electrodes (X), a photoconductor (22) electrically connected to either the segment electrode (X) or the common electrode (Y) and arranged in a pixel composed of an area of intersection between the segment electrode (X) and the common electrode (Y), a transparent island electrode (23) electrically connected to the photoconductor (22) and arranged in between the segment electrode (X) and the common electrode (Y) relevant to the pixel, liquid crystals (51) interposed between the island electrode (23) and an electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22), and a polarizer (52) for controlling a polarization direction of only light applying on a side of the electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22), said light being to able to reach the photoconductor (22) when the light passed through the polarizer (52);

a display illumination light source (11) which radiates display illumination light in displaying an image on a pixel matrix composed of areas of intersections between the plural segment electrodes (X) and the plural common electrodes (Y) of the display unit (1);

a document illumination light source (11) which radiates document illumination light in copying an optical image of a document into the pixel matrix of the display unit (1);

a control light source (11) which radiates control light for optically controlling turning-on and turning-off of a voltage to be applied to liquid crystals (51) of the display unit (1);

a display control circuit (6) which generates a display signal for displaying an image on the pixel matrix of the display unit (1);

an image input control circuit (8) which generates an image input signal for copying an optical image of the document into the pixel matrix of the display unit (1);

an image read control circuit (7) which generates an image read signal for reading image data written in the liquid crystals (51) of each pixel constituting the pixel matrix of the display unit (1) in the form of an electric signal;

a segment electrode driving circuit (3) which drives the segment electrode (X) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from the image read control circuit (7);

a common electrode driving circuit (2) which drives the common electrode (Y) based on the display signal from the display control circuit (6), the image input signal from the image input control circuit (8), or the image read signal from the image read control circuit (7);

an image data detection circuit (9) which detects the image data written in the pixel matrix of the display unit (1) in the form of an electric signal; and

a control circuit (13) which copies the optical image of the document into the pixel matrix by controlling the image input control circuit (8), the document illumination light source (11), and the control light source (11) in an image input mode, reads the image data written in the pixel matrix in the form of an electric signal by controlling the image read control circuit (7), the image data detection circuit (9), and the control light source (11) in an image read mode, and displays

an image on the pixel matrix by controlling the display control circuit (6) and the display illumination light source (11) in an image display mode.

5. An image input device-integrated type display device as claimed in Claim 4, wherein
ferroelectric liquid crystals (51) are used as the liquid crystals (51).

6. An image input device-integrated type display device as claimed in Claim 5, wherein
the image data detection circuit (9) detects a quantity of electric charges charged according to the image data at the island electrode (23) of each pixel constituting the pixel matrix of the display unit (1),
the control light source (11) can irradiate light one by one on each electrode which is one of the segment electrode (X) and the common electrode (Y) and is not electrically connected to the photoconductor (22), and
the control circuit (13) reads the image data written in pixel matrix in the form of an electric signal by detecting a quantity of electric charges charged at the island electrode (23) of the pixel relevant to the one segment electrode (X) or common electrode (Y) which is selected by being irradiated by light of the control light source (11) in the image read mode.

7. An image input device-integrated type display device as claimed in Claim 1, further comprising an input pen (10) which has a light source (41) and emits light from the light source (41) outwardly through its tip end, and wherein
the control circuit (13) controls the image input control circuit (8) and the control light source (11) in a pen input mode to allow an image input by means of the input pen (10) to be written into the pixel matrix.

8. An image input device-integrated type display device as claimed in Claim 4, further comprising an input pen (10) which has a light source (41) and emits light from the light source (41) outwardly through its tip end, and wherein
the control circuit (13) controls the image input control circuit (8) and the control light source (41) in a pen input mode to allow an image input by means of the input pen (10) to be written into the pixel matrix.

9. An image input device-integrated type display device as claimed in Claim 1, wherein
one of the two transparent substrates (28, 29) of the display unit (1) is provided with a micro lens (27) for condensing incident light thereto.

10. An image input device-integrated type display device as claimed in Claim 4, wherein
one of the two transparent substrates (28, 29) of the display unit (1) is provided with a micro lens (27) for condensing incident light thereto.

11. An image input device-integrated type display device as claimed in Claim 1, wherein
at least one of the two transparent substrates (28, 29) of the display unit (1) is comprised of a plate-shaped optical fiber array (61) where optical fibers (62) each having a specified length are arranged two-dimensionally with axial directions of the optical fibers (62) extended in a thickness direction of the optical fiber array (61).

12. An image input device-integrated type display device as claimed in Claim 4, wherein
at least one of the two transparent substrates (28, 29) of the display unit (1) is comprised of a plate-shaped optical fiber array (61) where optical fibers (62) each having a specified length are arranged two-dimensionally with axial directions of the optical fibers (62) extended in a thickness direction of the optical fiber array (61).

13. An image input device-integrated type display device as claimed in Claim 1, wherein
the display illumination light source (11), the document illumination light source, and the control light source are comprised of one plate-shaped light source (11), and a side portion of the plate-shaped light source (11) is pivotally mounted to a side portion of the display unit (1).

14. An image input device-integrated type display device as claimed in Claim 4, wherein
the display illumination light source, the document illumination light source, and the control light source are comprised of one plate-shaped light source (11), and a side portion of the plate-shaped light source (11) is pivotally mounted to a side portion of the display unit (1).

15. A device which is selectively operable in a first mode for image input by light illumination, and a second mode for image display by the application of electrical signals, the device comprising:
a first set of parallel elongate transparent electrodes;
a second set of parallel elongate transparent electrodes spaced from and extending transverse to the electrodes of said first set to define an array of pixel areas at their crossing points;
a corresponding array of transparent island electrodes which are electrically unconnected to each other and are disposed at the respective pixel areas between the first and second

sets of elongate electrodes;

a corresponding array of photoconductive elements interconnecting the respective island electrodes and the electrodes of said first set, so that each line of said photoconductive elements connects a corresponding line of island electrodes to a respective said electrode of the first set;

a display medium disposed between said island electrodes and the second set of elongate electrodes;

means operable in the second mode to illuminate all of the photoconductive elements so that display control signals applied to the first elongate electrodes are applied to the island electrodes; and

means operable in the first mode to apply a predetermined image input voltage to said first electrodes, and to selectively illuminate the photoconductive elements so as to cause said image input voltage to be applied to imagewise selected island electrodes.

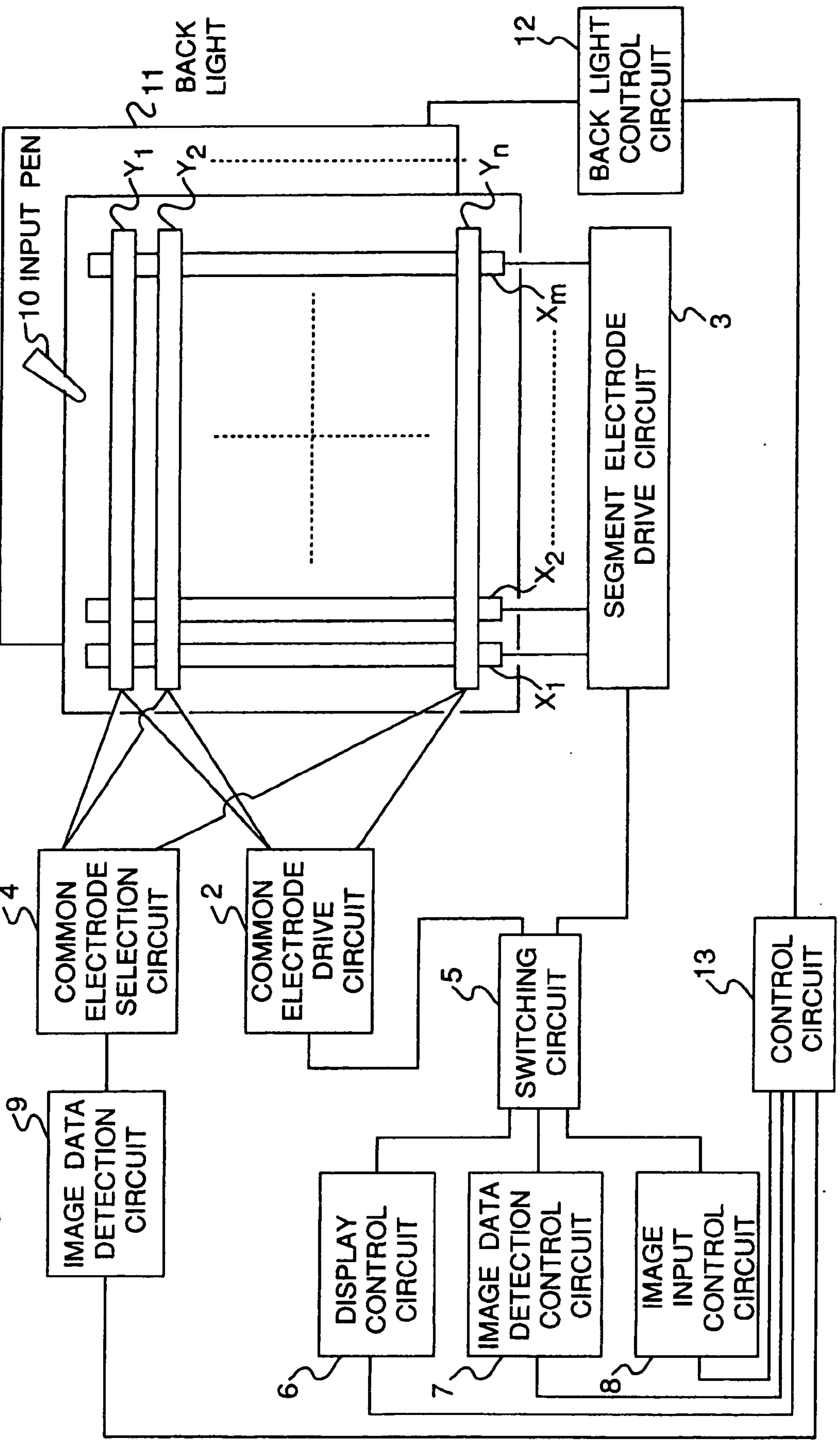

1 IMAGE INPUT DEVICE-INTEGRATED TYPE DISPLAY UNIT
10 INPUT PEN
11 BACK LIGHT
12 BACK LIGHT CONTROL CIRCUIT
Y_1
Y_2
Y_n
X_1
X_2
X_m
3 SEGMENT ELECTRODE DRIVE CIRCUIT
4 COMMON ELECTRODE SELECTION CIRCUIT
2 COMMON ELECTRODE DRIVE CIRCUIT
5 SWITCHING CIRCUIT
13 CONTROL CIRCUIT
9 IMAGE DATA DETECTION CIRCUIT
6 DISPLAY CONTROL CIRCUIT
7 IMAGE DATA DETECTION CONTROL CIRCUIT
8 IMAGE INPUT CONTROL CIRCUIT

Fig.1

Fig.2

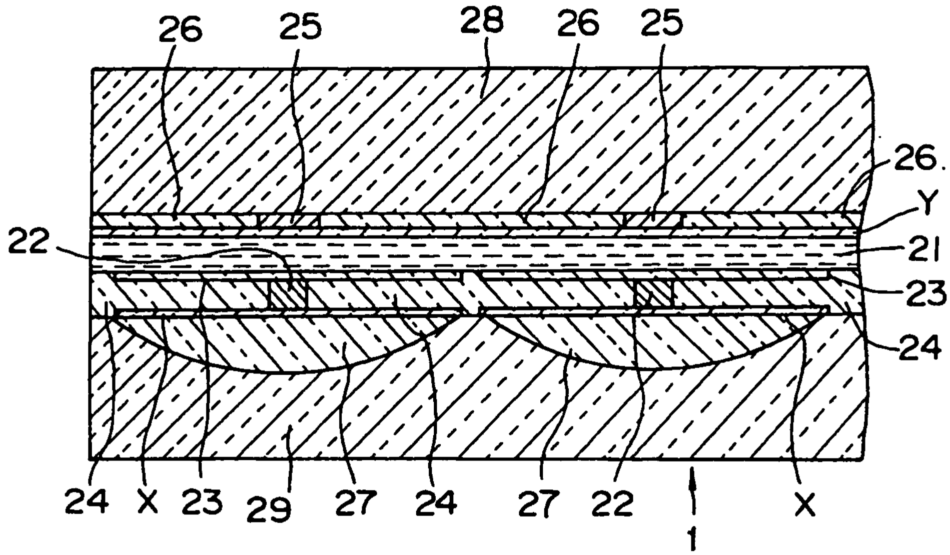

26
25
28
26
25
26
Y
22
21
23
24
24
X
23
29
27
24
27
22
1
X

Fig.3

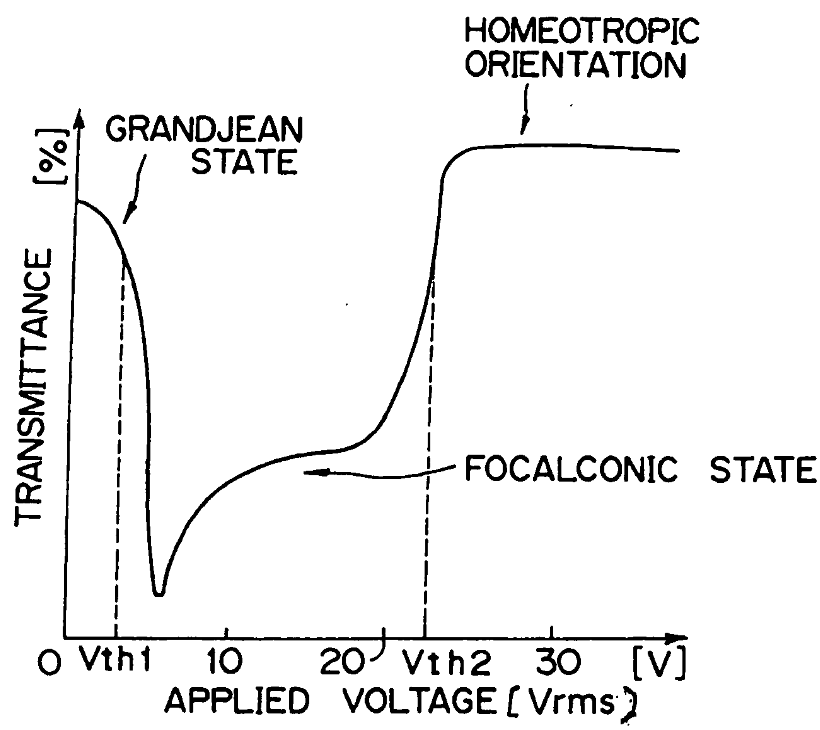

HOMEOTROPIC ORIENTATION
GRANDJEAN STATE
[%]
TRANSMITTANCE
FOCALCONIC STATE
0
Vth1
10
20
Vth2
30
[V]
APPLIED VOLTAGE [Vrms]

Fig.4

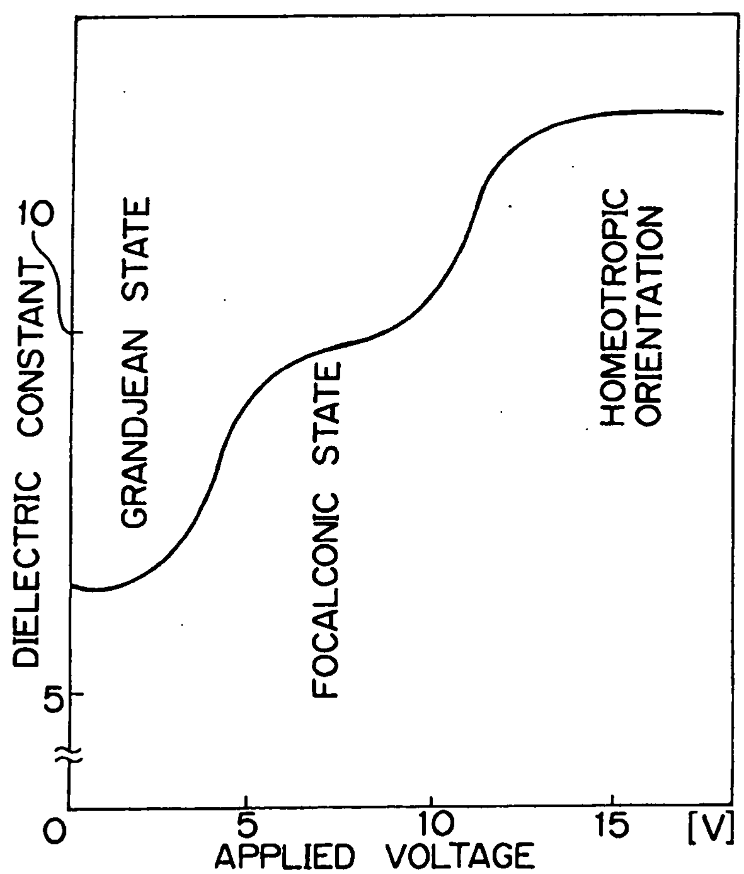

DIELECTRIC CONSTANT
10
5
0
5
10
15
[V]
APPLIED VOLTAGE
GRANDJEAN STATE
FOCALCONIC STATE
HOMEOTROPIC ORIENTATION

Fig.5(a)

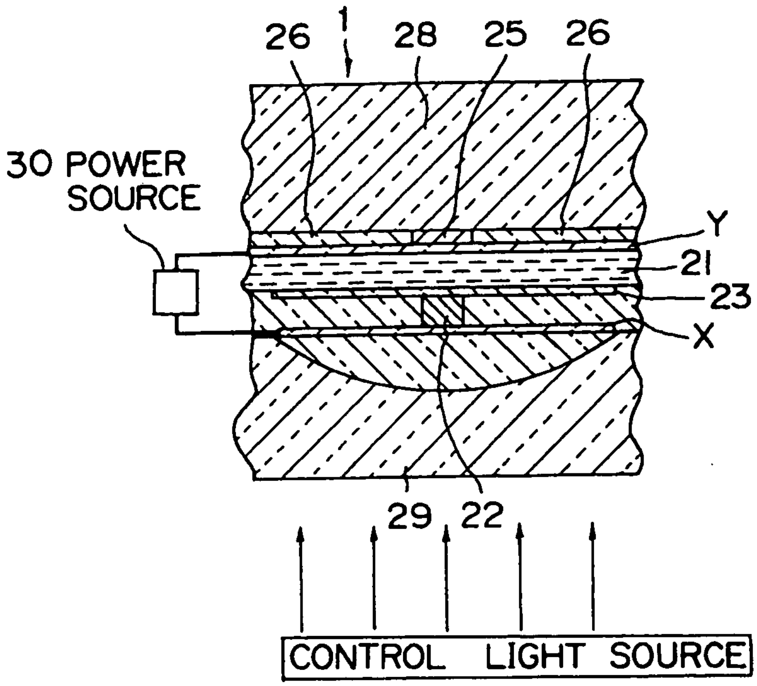


Fig.5(b)

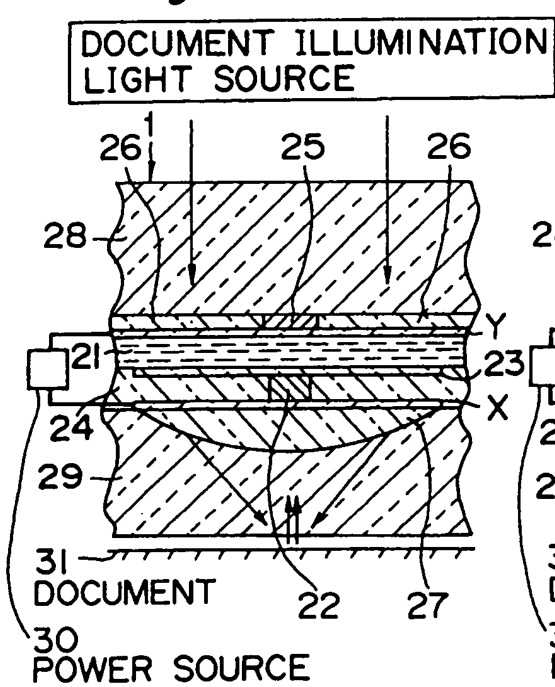


Fig.5(c)

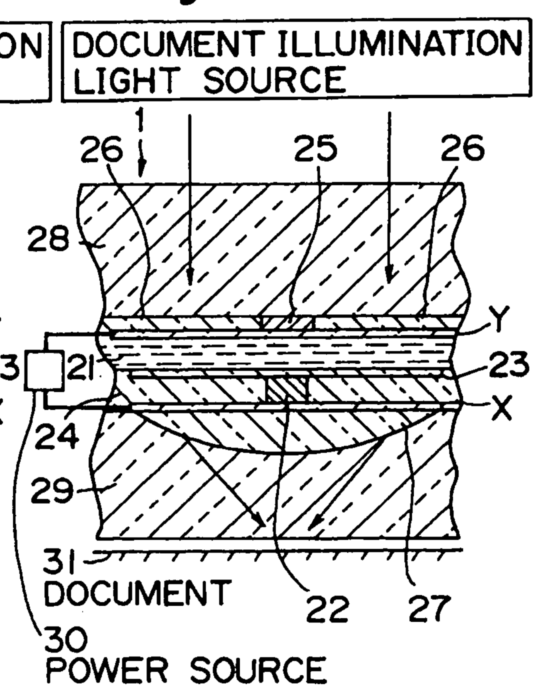


Fig.6

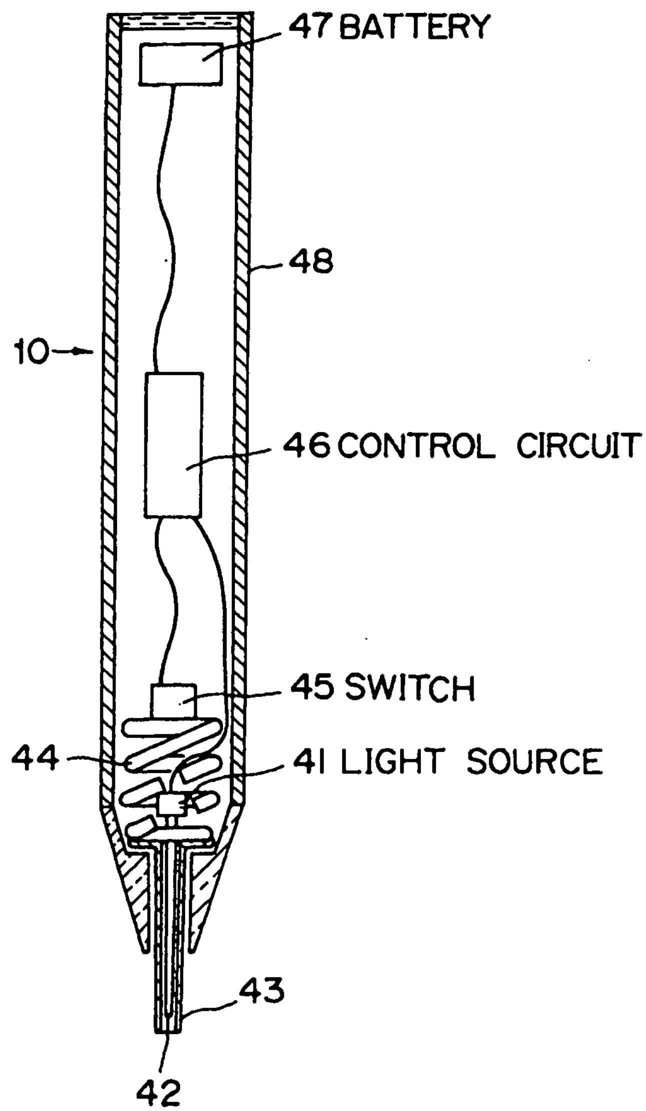
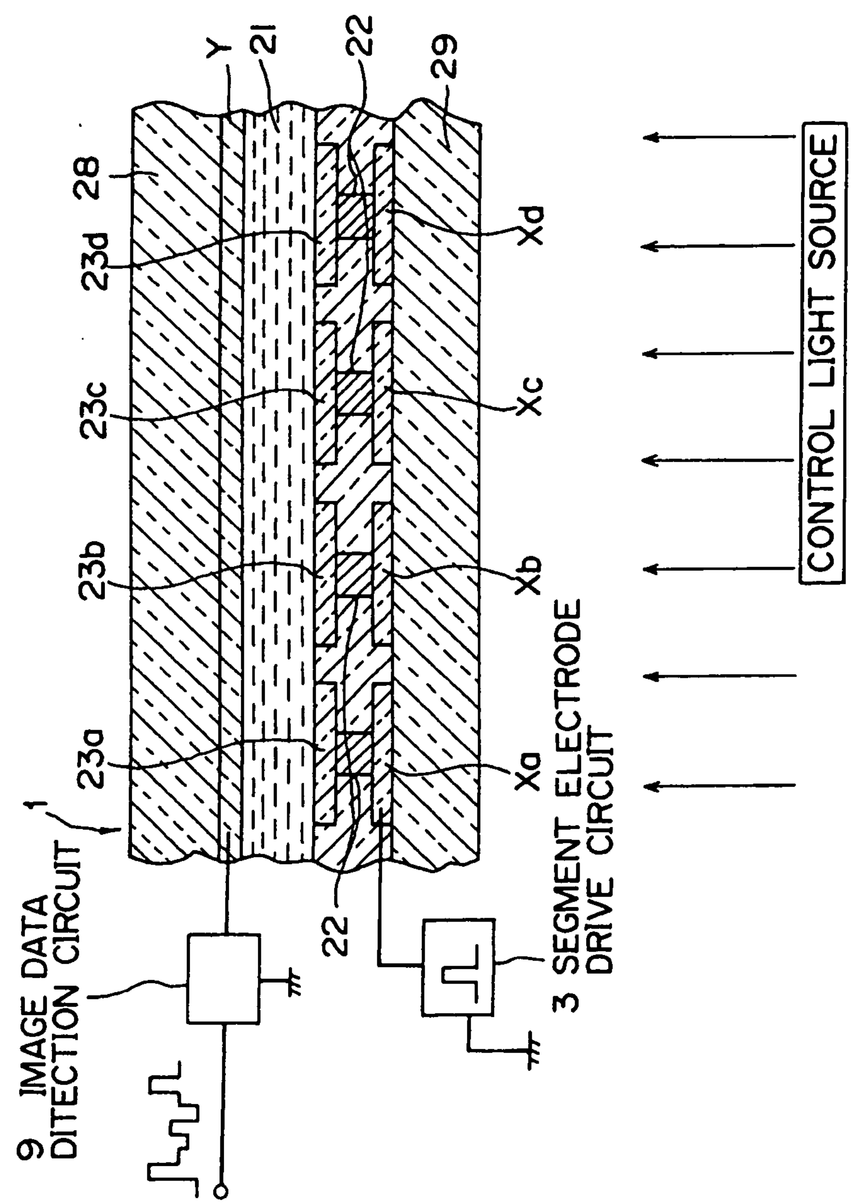
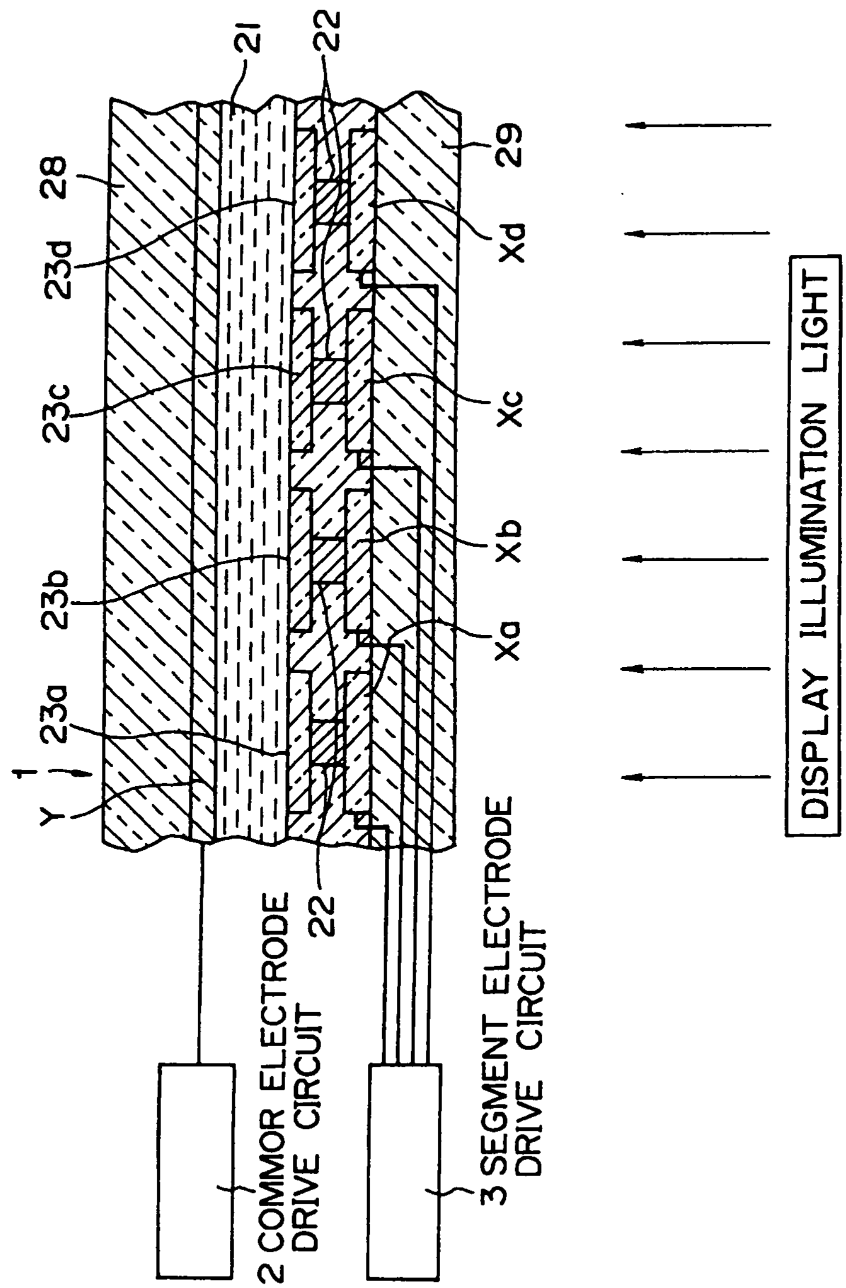

47 BATTERY
48
10
46 CONTROL CIRCUIT
45 SWITCH
44
41 LIGHT SOURCE
43
42

Fig.7



9 IMAGE DATA DITECTION CIRCUIT
1
23a
23b
23c
23d
28
Y
21
22
29
Xa
Xb
Xc
Xd
3 SEGMENT ELECTRODE DRIVE CIRCUIT
CONTROL LIGHT SOURCE

Fig.8



21
22
28
29
23d
Xd
23c
Xc
23b
Xb
23a
Xa
1
Y
22
DISPLAY ILLUMINATION LIGHT
2 COMMOR ELECTRODE DRIVE CIRCUIT
3 SEGMENT ELECTRODE DRIVE CIRCUIT

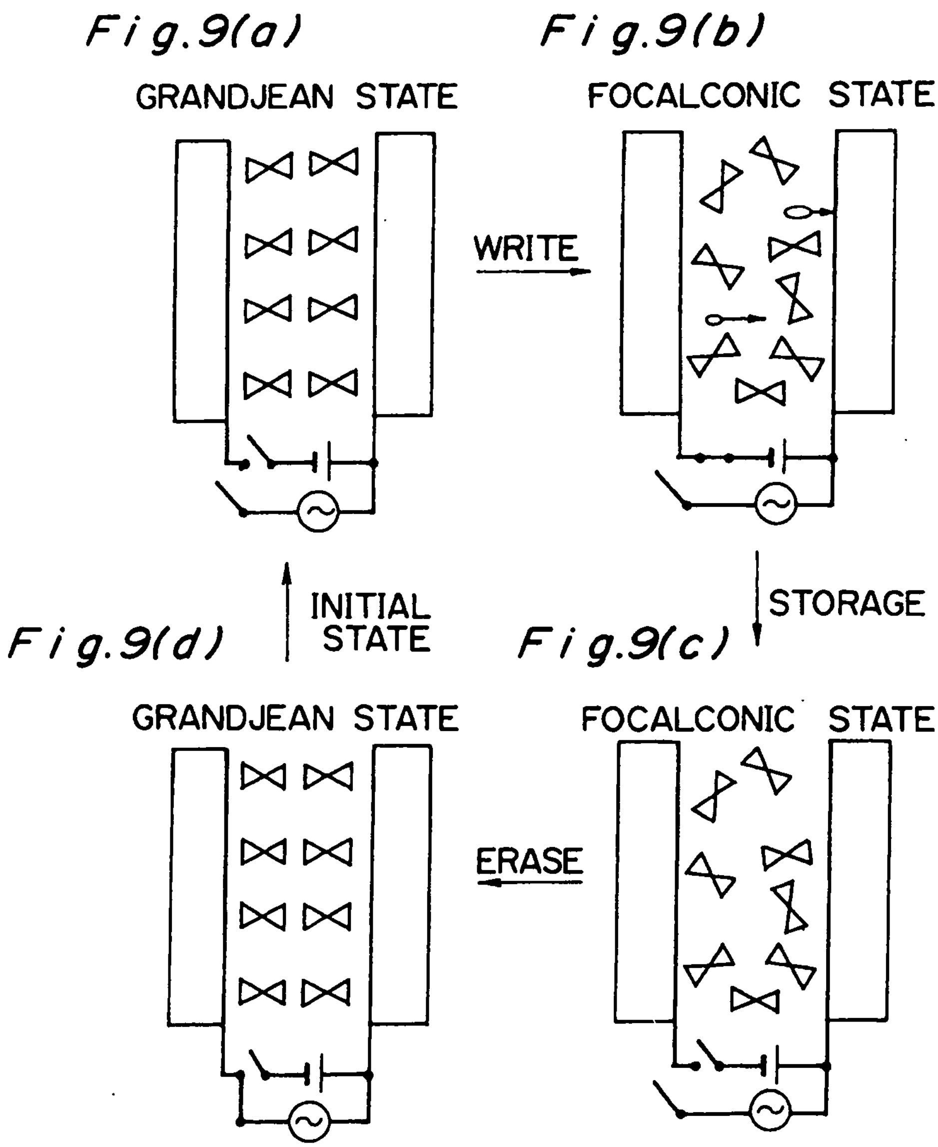


Fig.9(a)

Fig.9(b)

Fig.9(c)

Fig.9(d)

Fig.10

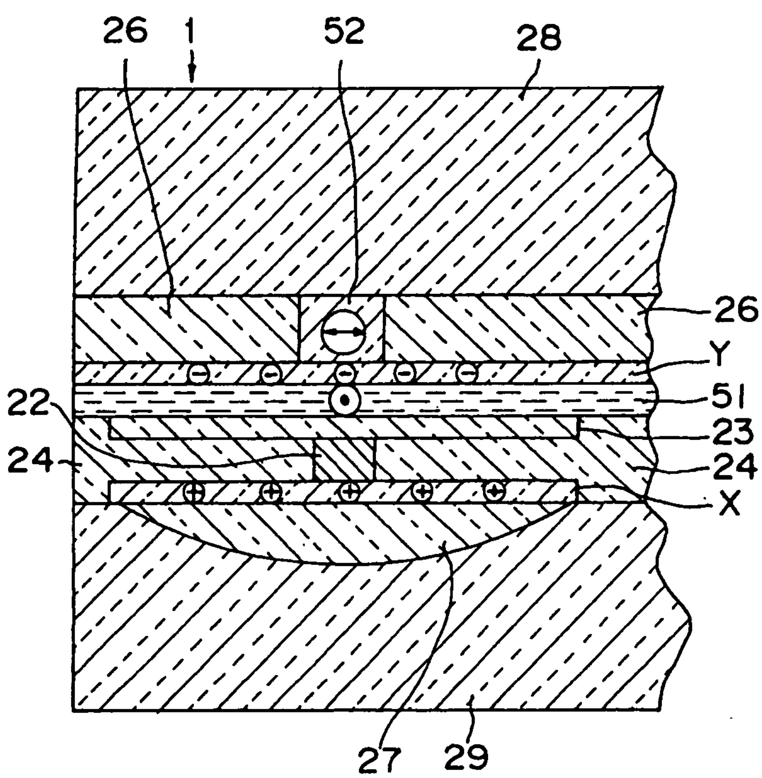


Fig.11(b)

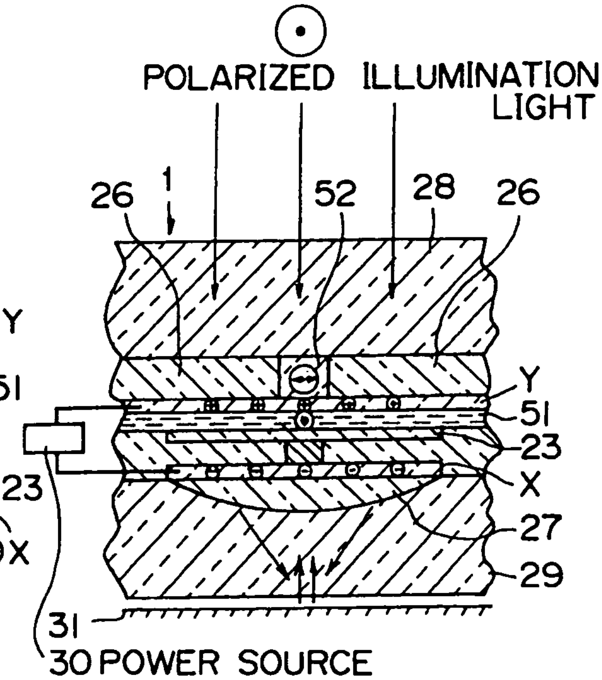


Fig.11(a)

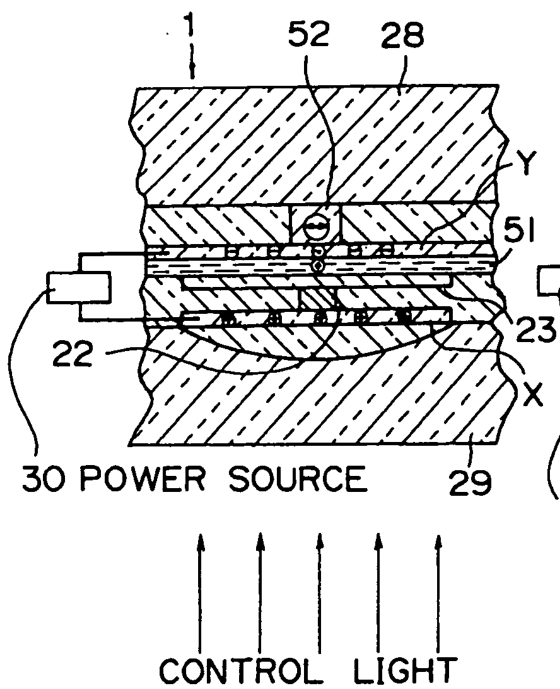


Fig.11(c)

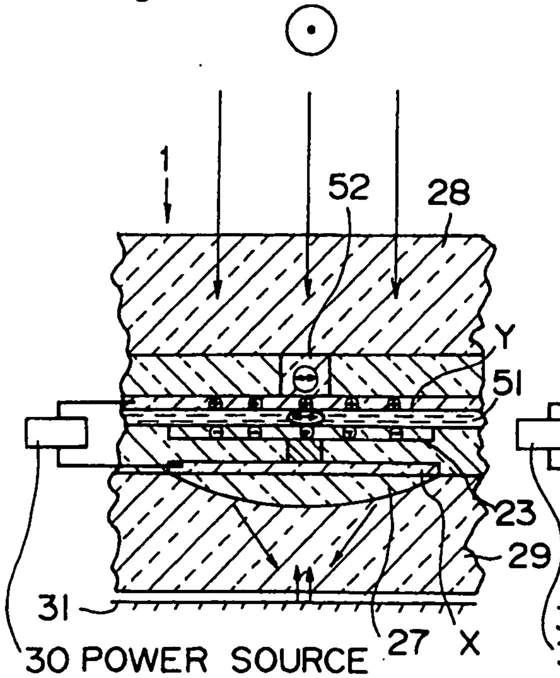


Fig.11(d)

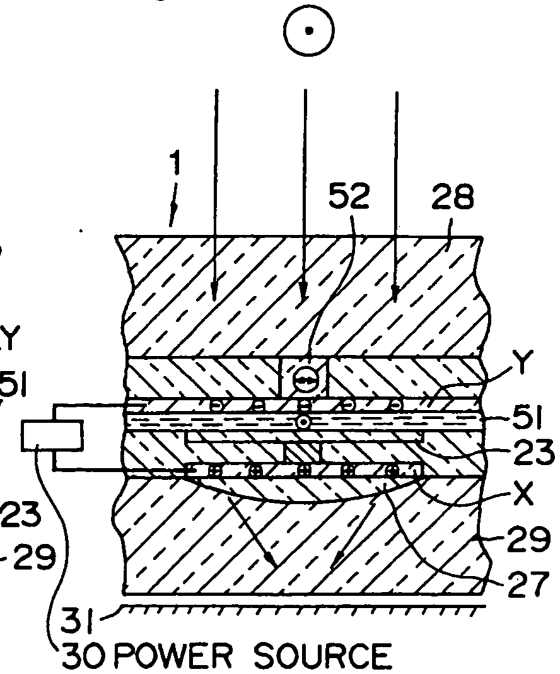


Fig.12(a)

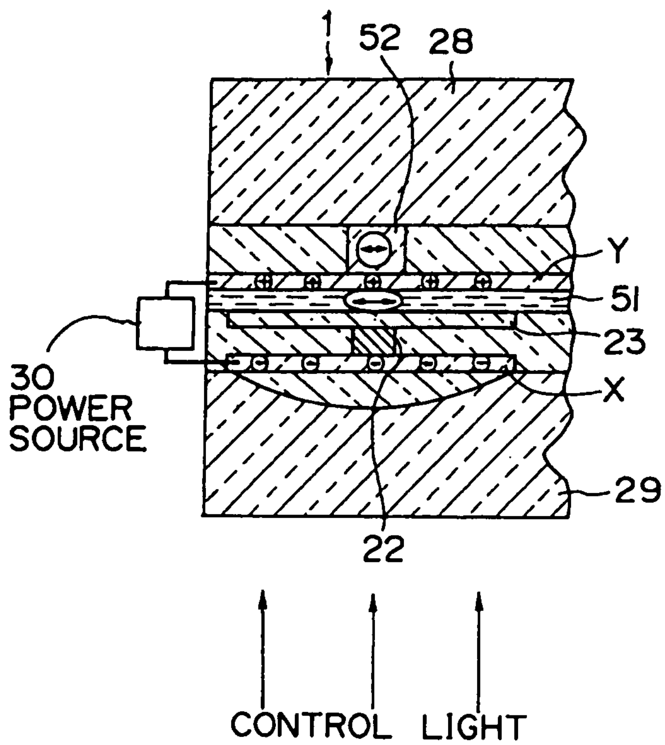


Fig.12(b)

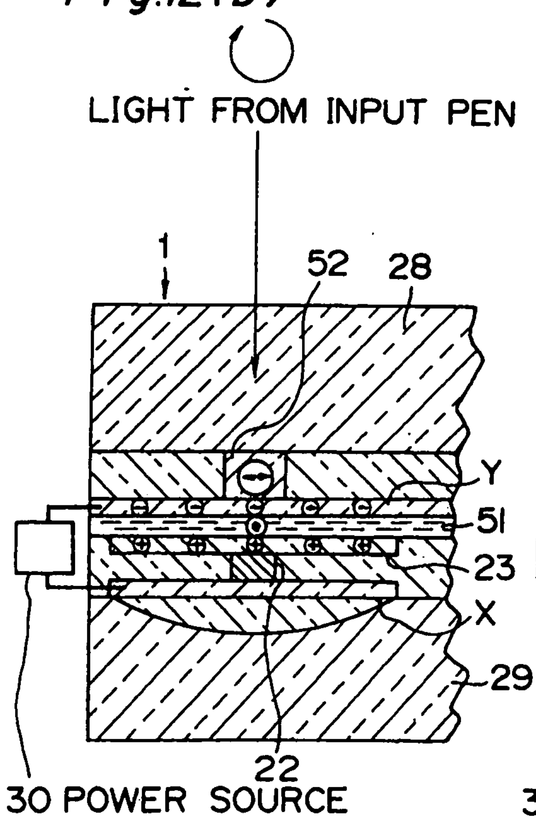


Fig.12(c)

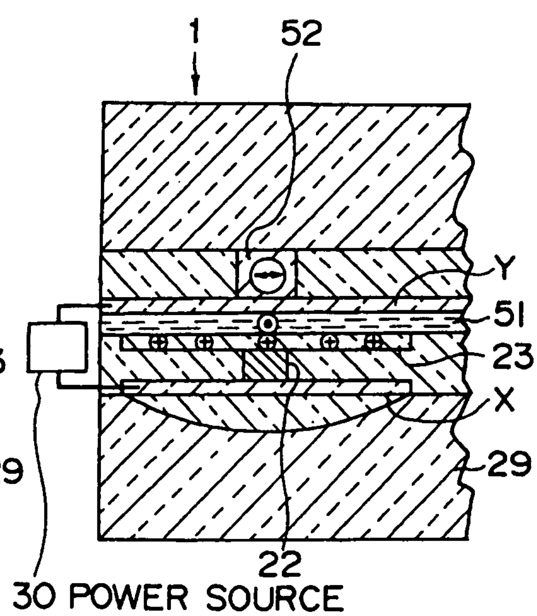


Fig.13(a)

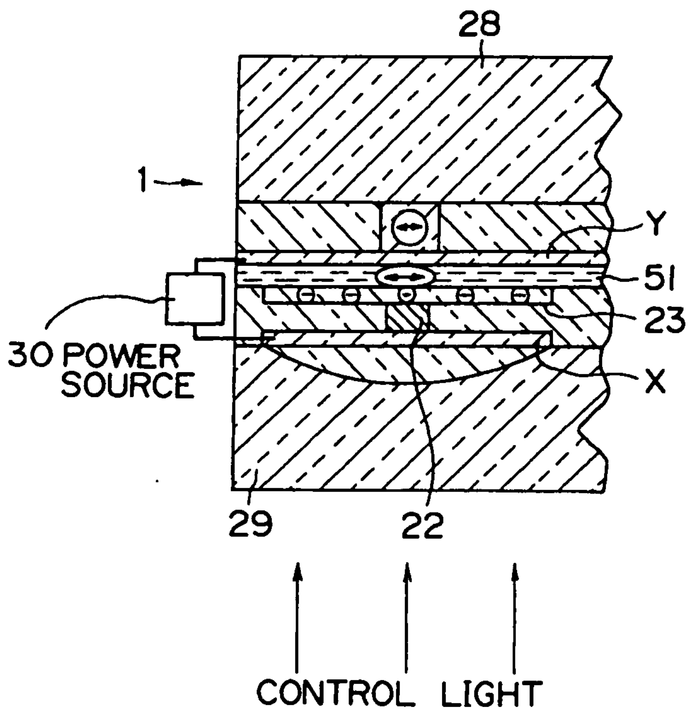


Fig.13(b)

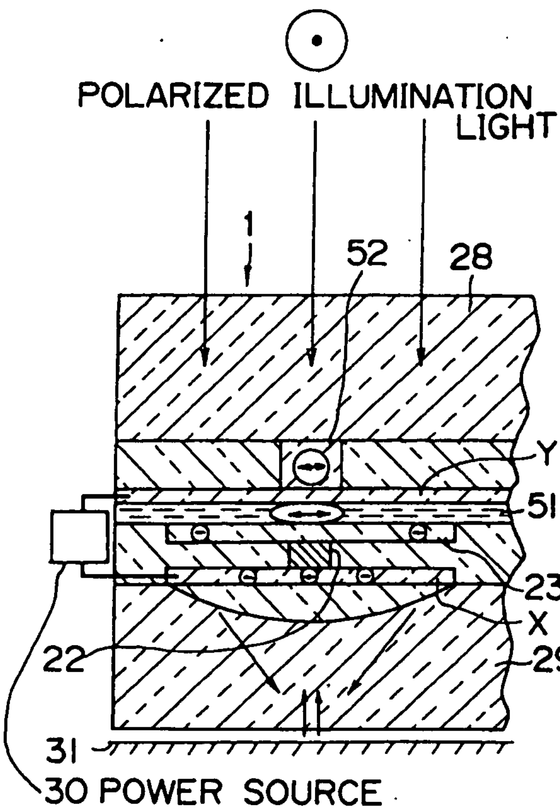


Fig.13(c)

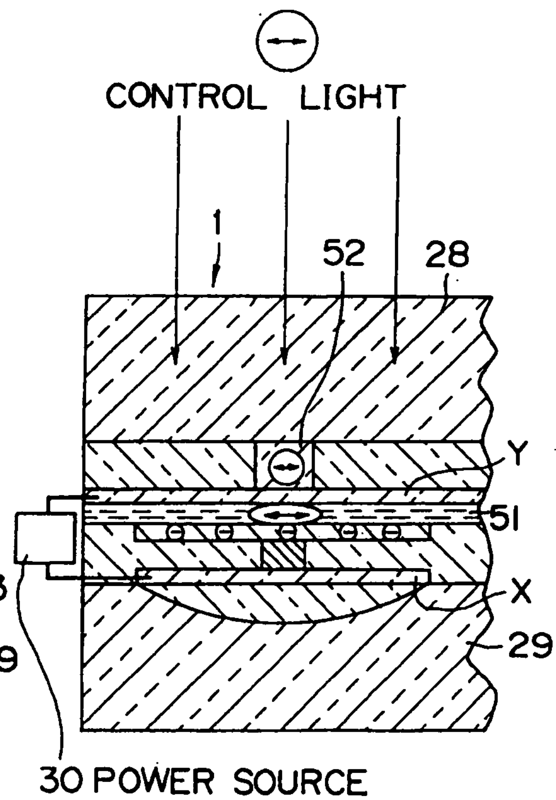


Fig.14(a)

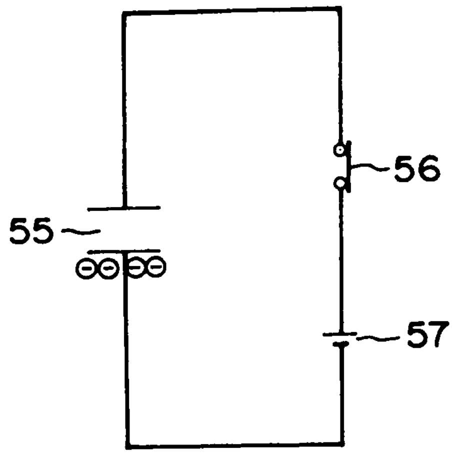


Fig.14(b)

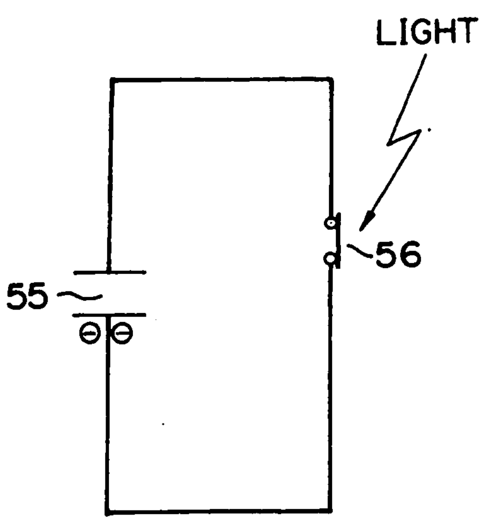


Fig.14(c)

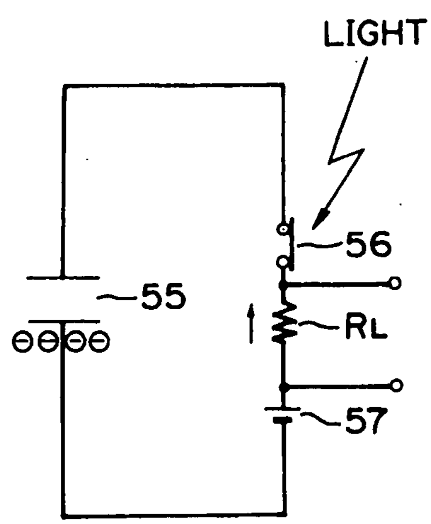


Fig.15(a)

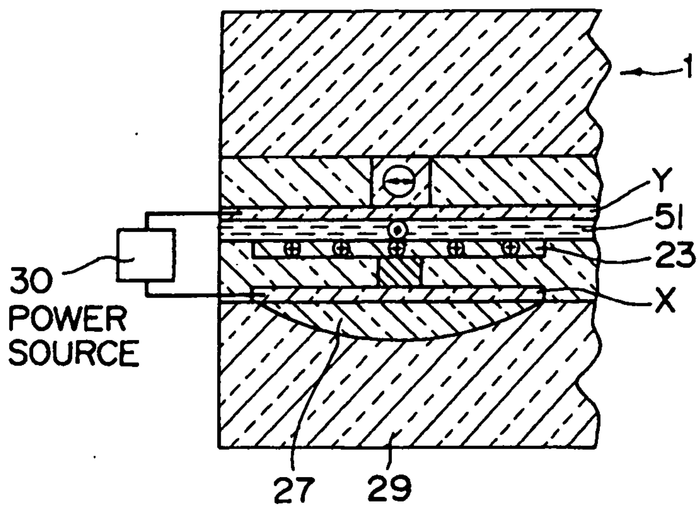


Fig.15(b)

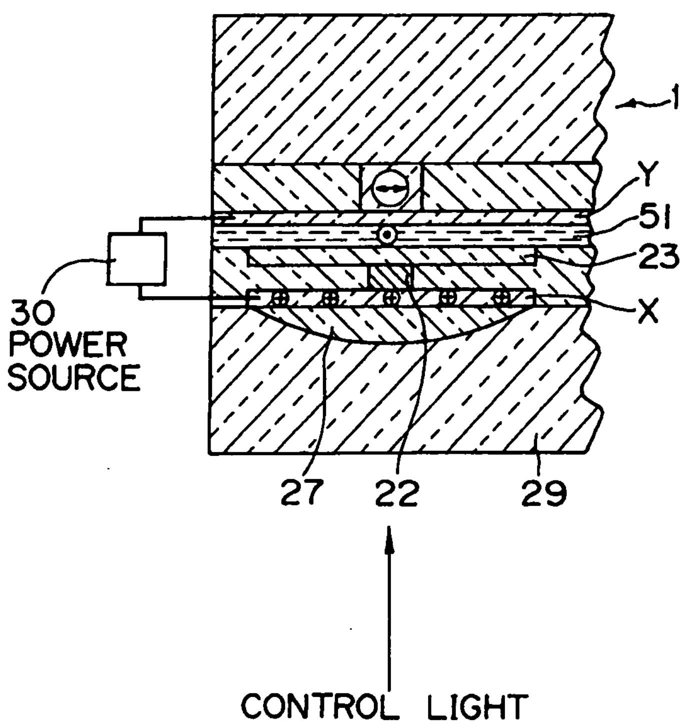


Fig.16(a)

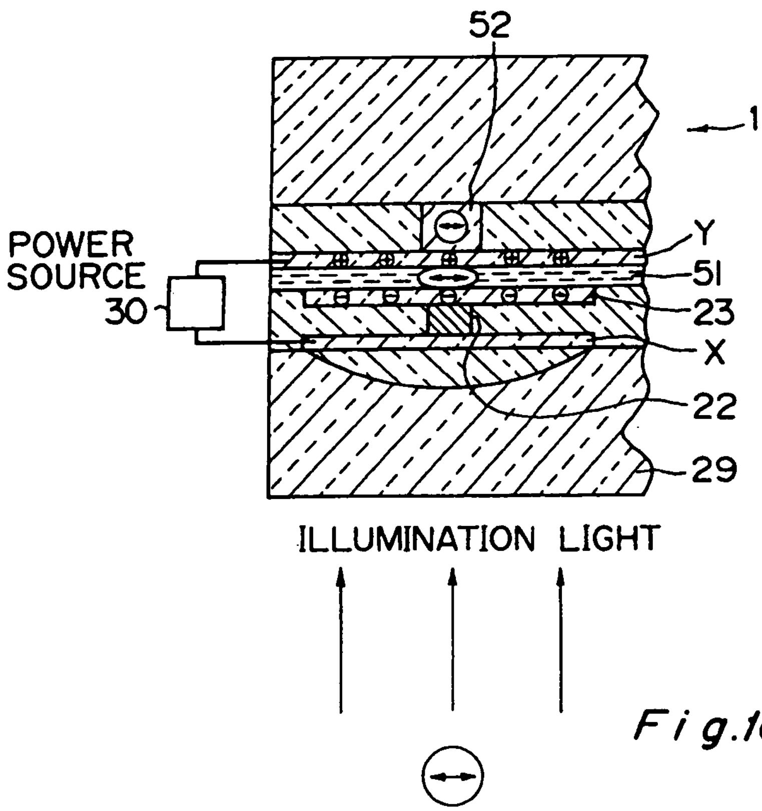


Fig.16(b)

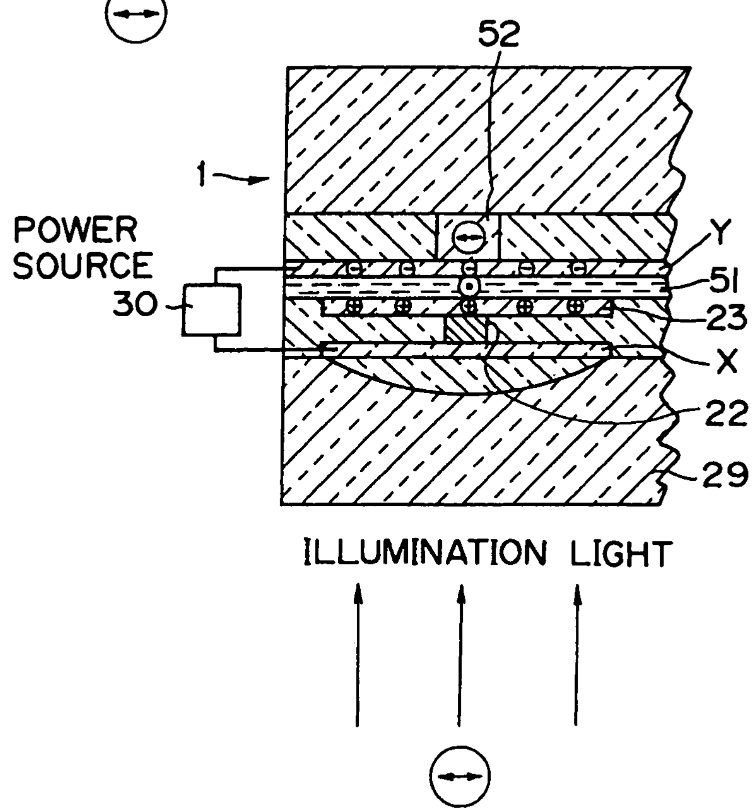


Fig.17

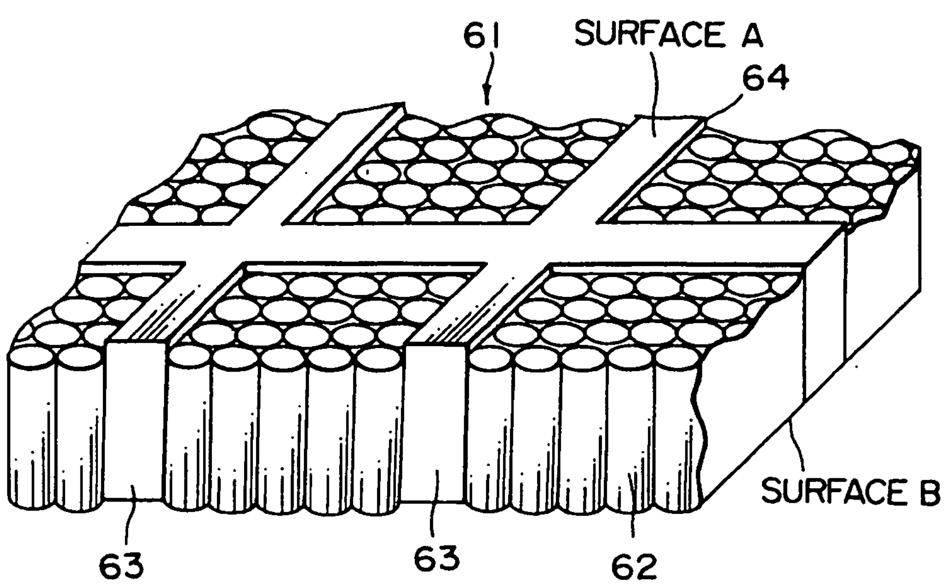


Fig.18(a)

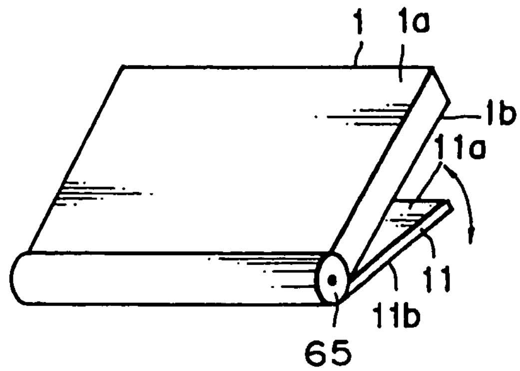


Fig.18(b)

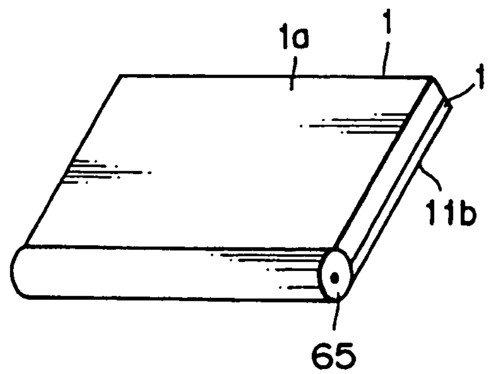
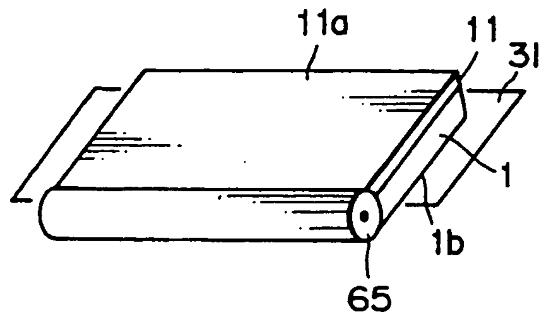


Fig.18(c)



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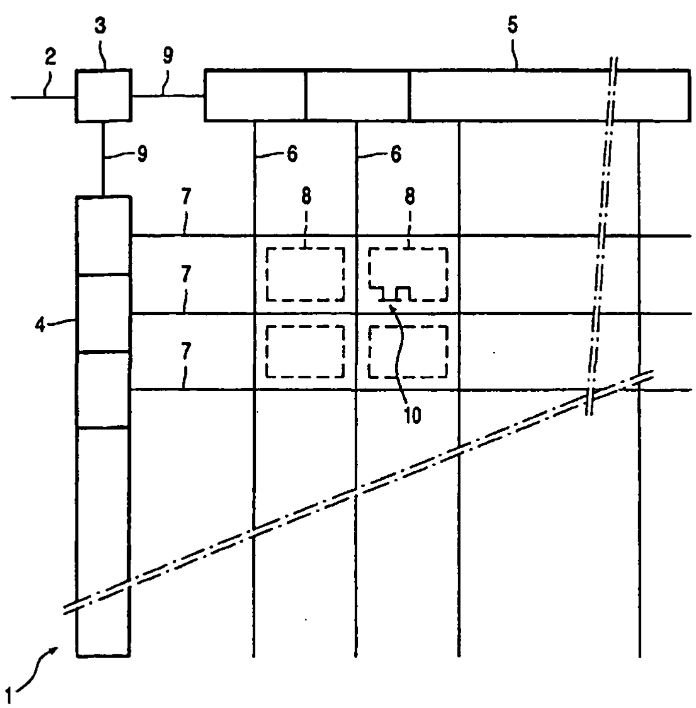
(54) Title: TOUCH SENSITIVE DISPLAY DEVICE



(57) **Abstract:** In a touch sensor the change in pixel impedance is measured from the sensing area directly (passive matrix) or through the address transistors (AMLCD) associated with the sensing area.

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Touch sensitive display device

The invention relates to a touch sensitive display device comprising a multiple of picture elements and means for driving at least one of said picture elements together with means for monitoring the impedance of at least one of said picture elements.

The display device is for instance a liquid crystal display device or a O(LED) display or a display based on electrochromic effects. For liquid crystal display devices the impedance of a picture element mainly consists of a capacitive element, whereas for electrochromic displays and O(LED) display devices, especially in reverse bias the impedance of a picture element mainly is resistive.

Such display devices have found widespread use in the computer industry and in handheld devices ranging from mobile telephones and price tags to palm top computers and organizers. Also the combination with a touching device such as a stylus has found widespread applications, while also a need for other ways of providing input via the display screen is felt.

USP 5,777,596 describes a touch sensitive liquid crystal display device that allows putting input into the associated device (e.g. a computer) by simply touching the display screen with a finger, a stylus or a pen. The device continuously compares the charge time of the liquid crystal display elements (picture elements) to a reference value and uses the result of the comparison to determine which elements are being touched.

One of the problems in said touch sensitive liquid crystal display device resides in restoring the right image after sensing. This is due to the fact that a blinking line is used which represents the switching of all picture elements in a row between two extreme states. When the blinking line reaches a certain row touching is detected by measuring the charging time of the picture elements. After measuring the picture elements are provided with adequate voltages to display the right image. In a similar way sensing by means of a blinking spot is disclosed in USP 5,777,596.

Such blinking however is visible on the display (artifacts)

Apart from using rather complex circuitry, in this way of sensing it is difficult to take into account the difference in liquid crystal display properties such as kick back which differs for writing odd or even frames. Moreover, if a reflective display device is used, internal DC bias voltages may be present whereby charging differs for writing odd or even frames. In DC –driving methods (low power liquid crystal displays, electrophoresis) no inversion occurs so the method cannot be used at all there.

The invention has among others as its goal to overcome these objections.

It has as a further goal to introduce more functionality into the touch sensitive liquid crystal display device.

To this end in a touch sensitive display device according to the invention provides the means for monitoring the impedance of at least one of said picture elements substantially and simultaneously sensing a change.in said impedance. In fact the invention provides a method of non-interactive measuring; the method of measuring does not interfere with the providing of driving voltages to the picture elements.

This does not only overcome the problem of providing blinking signals but also offers new possibilities of touch sensing such as

i) sensing touch inputs at different places on the display screen

ii) disabling part of the display screen for touch sensing

Both possibilities offer substantial advantages both in computer and telecommunication applications.

Sensing touch inputs substantially simultaneously at different places on the display screen offers possibilities such as detecting the impact of fingers or pencils on different places of the display screen. This is a useful item in e.g. flat screen (computer) devices in which the keyboard functions have been realized as touch functions on the screen. It is for example possible to detect simultaneous touching of CRTL, ALT and DEL pressing; similarly in e.g. drawing programs the simultaneous touching of two points with a pen may immediately display a straight line, while at the same time via a third touching (area) this line may receive a certain curvature or hatching etc. Further applications are e. g. gaming or features which enables either the user or a service provider or receiver of a service to enable and disable a part of the touch screen. data input, e.g. obtained via the Internet may prevent certain parts (displaying logos) to be disturbed or disable certain menu bars for unauthorized users.

On the other hand disabling part of the display screen for touch sensing may be used in a cellular phone preventing the read out from being disturbed

The sensing itself may be performed by measuring a change in voltage or a change in frequency.

The change in impedance within a single picture element, e.g. the pixel capacitance in a liquid crystal display device, generally is much smaller than the total capacitance of the other pixels (in a passive matrix display), or the total capacitance of crossovers and stray capacitances in the columns and rows (in an active matrix display). This reduces the sensitivity of a touch sensor. In an active matrix liquid crystal display (AMLCD) such a total capacitance is typically 10-100 times higher than the pixel capacitance – in a passive matrix display the factors are even higher.

One if the solutions according to the invention is to ensure that many pixels along the column (or row) are sensed at the same moment. In this case, the touch signal will increase with the number of pixels being sensed, whilst the background impedance will remain constant. In this way the signal to noise ratio increases.

To this end a first embodiment of a touch sensitive display device according to the invention provides means for monitoring the impedance (capacitance) of at least one row of picture elements, while in a second embodiment the means for monitoring impedance monitor at least the impedance (capacitance) of one column of picture elements. Also monitoring of the impedance of a block of picture elements is possible.

In a preferred embodiment of a touch sensitive display device the means for monitoring the impedance (capacitance) comprise means for comparing the impedance (capacitance) of the picture elements with a reference value.

Said reference value may be a fixed value but preferably is determined by impedance (capacitance) values of said picture elements having voltages outside the transition region of the liquid crystal picture elements. On the other hand it may be determined on a dynamic basis in which case the means for comparing the impedances (capacitances) comprise means to determine the reference value.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Figure 1 schematically shows a liquid crystal device,

Figure 2 shows a voltage transmission curve of a liquid crystal device,

Figure 3 shows a first embodiment of a part of a touch sensitive liquid crystal device according to the invention, while

Figures 4, 5 and 6 show further embodiments of a part of a touch sensitive liquid crystal device according to the invention. The Figures are diagrammatic and not drawn to scale. Corresponding elements are generally denoted by the same reference numerals.

Figure 1 is an electric equivalent circuit diagram of a part of a display device 1 to which the invention is applicable. It comprises in one mode of driving, called the "passive mode", a matrix of pixels 8 defined by the areas of crossings of row or selection electrodes 7 and column or data electrodes 6. The row electrodes are consecutively selected by means of a row driver 4, while the column electrodes are provided with data via a data register 5. To this end, incoming data 2 are first processed, if necessary, in a processor 3. Mutual synchronization between the row driver 4 and the data register 5 takes place via drive lines 9.

In another mode of driving, called the "active mode", signals from the row driver 4 select the picture electrodes via thin-film transistors (TFTs) 10 whose gate electrodes are electrically connected to the row electrodes 7 and the source electrodes are electrically connected to the column electrodes. The signal which is present at the column electrode 6 is transferred via the TFT to a picture electrode of a pixel 8 coupled to the drain electrode. The other picture electrodes are connected to, for example, one (or more) common counter electrode(s). In Figure 1 only one thin-film transistor (TFTs) 10 has been drawn, simply as an example.

Figure 2 shows a voltage transmission curve of a liquid crystal device. It is know that in many kinds of LC effects the dielectric constant of the liquid crystal changes with the pixel voltage. So at voltage V_{th}, where in this case the transmission starts to decrease and has for instance reached a level of 90 % a pixel has, under normal (untouched) circumstances, a capacitance C_{th}. Under the same circumstances at voltage V_{sat}, where in this case transmission has for instance reached a level of 10 % a pixel has, under normal (untouched) circumstances, a capacitance C_{sat}. These values preferably are used as reference value to detect the measure of change after touching (depressing) of a pixel leading to a variation in the liquid crystal layer thickness. Similar voltage transmission curves are shown by display devices based on electrowetting and some display devices based on electrophoresis.

In general the pixel capacitance of one pixel is overshadowed by the capacitance of other pixels (in passive matrix), cross overs and stray capacitances (active matrix) in the columns and rows. This reduces the sensitivity.

One solution to this is to ensure that many pixels along the column 6 (or row 7) are sensed at the same moment. In this case, the touch signal will increase with the number of pixels being sensed, whilst the background capacitance will remain constant. In this way the signal to noise ratio will increase. In a preferred embodiment, the touch sensing procedure will involve many rows 7 being addressed at the same time (active matrix) or many columns 8 being connected to increase the touch signal.

In the embodiment of Figure 3, a keypad, most pixels within a touch sensitive display part 11 are in a defined state (background pixels), such as white liquid crystal display pixels, which at (or below) their threshold voltage V_{th} have a known capacitance. In the example (passive LCD) keypad, only a few pixels are dark pixels, viz. the numbers themselves, and have higher capacitance whilst the majority are white background pixels. In particular, many rows 22 and columns 23 (those between the numbers) comprise entirely background pixels, and several blocks 24 of pixels between the numbers are attached to both rows and columns where no dark pixels are present.

In these devices these blocks of background pixels can be used for touch sensing, in which touch sensing is for instance performed during the blanking time between two frames. If, for instance, all rows driving pixels in the top quarter 12a of the display, drive sensing pixel blocks and the columns are used for direct sensing of the pixel capacitance, one is able to detect the charge flowing along the block of columns when the LC polarity of the sensing pixels in these columns is inverted (i.e. from $-V_{th}$ to V_{th}). The normal charge during inversion would be

$$Q_{nominal} = 2 \times V_{th} \times C_{total} \qquad (1)$$

with C_{total} the capacitance of the block of sensing pixels in the top quarter of the display. In any block of sensing pixels where the capacitance is modified by touching the display (either pressure or stray capacitance) the capacitance will increase by C_{touch}.

$$Q_{touch} = 2 \times V_{th} \times (C_{total} + C_{touch}) \qquad (2)$$

By comparing this to the known $Q_{nominal}$ value, one can determine whether the display has been touched in the top set of numbers e.g. by measuring the charging current, i.e. the difference in impedance (capacitance).

Subsequently, the three remaining blocks 12b, 12c, 12d of rows are activated and the touch sensing continues until the display is completely scanned.

A similar reasoning applies to active matrix LCDs, in which the charging current is flowing through the address TFTs.

During sensing, the dark pixels where data is present (i.e. the numbers on the keypad) are never addressed, and as such they will maintain their grey value (during the blanking period). In the example of Figure 3 however, the groups of rows and columns to be used to provide the image may be completely separated from the groups of rows and columns to carry out the touch sensing. In this case it is possible to carry out the touch sensing operation during the frame period. For example, if the keyboard (or a menu) data were being presented in a low frame rate, low power mode (e.g. at 5Hz or lower refresh rate) it is still possible to carry out touch sensing at a much higher frequency. This results in a more rapid touch response, with no delay due to waiting for the next blanking period between two frames. In this preferred embodiment, it is possible to incorporate several touch measurement periods within one frame time. The use of several touch measurement periods within one frame time improves the reliability of the system.

In more complicated displays (monitors, electronic games) it may be advantageous to be able to do the touch sensing while all or most of the display is active. This implies that lots of pixels are at different (and changing) voltages and hence have different capacitances. To be able to detect a reference value in such a device a similar approach is taken into account again, but a field memory is used. By signal processing the expected nominal capacitance of the sensing area is determined e.g. by summing the individual charges from each pixel.

$$Q_{nominal} = \Sigma\, (2 \times V_{lc} \times C_{pixel}) \qquad (3)$$

Now a look-up-table (or similar device) is used to determine C_{pixel} at a given pixel voltage (temperature, frame time etc.). In any block of sensing pixels where the capacitance is modified by touching the display (either pressure or stray capacitance) the capacitance will increase by C_{touch} again, leading to

$$Q_{touch} = \Sigma (2 \times V_{lc} \times (C_{pixel} + C_{touch})) \quad (4)$$

Again, the touch position can be determined by comparing the calculated nominal charge and measuring the charging current to the block of display pixels.

In general, one current amplifier will now be used to sense pixels simultaneously within a column where touch sensing is required, and that it will no longer be possible to probe many pixels simultaneously by addressing multiple rows.

In a further embodiment pixels (or block of pixels) with the same nominal capacitance (for example all pixels at the lowest pixel voltage V_{th}) and corresponding known capacitance are used as a reference. Touch sensing is now carried out using only these pixels and by comparing the measured pixel capacitance to the known, nominal value defined in equation (1). In this method however the touch position of touch sensing will change dynamically depending upon the image content.

As an alternative a reset is applied to drive pixels to a predefined capacitance before the touch sensor operation is carried out. Detection is then carried out with reference to the known nominal capacitance value, as described above, (using equations (1) and (2)). Especially in LCD-displays, where a pulsed backlight is applied (LCD TV's and other multi-media applications where video is shown) it is possible to carry out the reset function during the dark period between pulses and carry out touch sensing without distorting the image.

In yet another approach, a scanning reset function could be applied, to reset the pixel to a predefined capacitance and carry out the touch sensing measurement just before the pixel is re-addressed.

In LCD applications, a reset to high voltage (e.g. black) is preferred, as the LC response time is shorter at high voltages. This means that the LC will reach its final capacitance more quickly, and touch sensing can be carried out with a higher frame rate. In addition, the LC capacitance varies less above a certain voltage (capacitance/voltage curve is less steep at higher voltages), so any pixels which have not completely reached their reset capacitance will only result in small errors.

In a further embodiment dummy pixels within the display are only used for touch sensing and not for displaying information. These pixels then have a known capacitance and sensing can again be carried out as described above. Distortion of the image by the presence of these dedicated pixels will have minimal perceptual impact if these pixels are arranged, for example, at the edge of the display. On the other hand these pixels may be arranged in the form of blocks (or even as larger segments) and distributed around the

display. The output of (several of) these sensors is then used to determine the position of the touch input.

In a modification of this embodiment these dedicated touch sensor pixels are arranged at regular spacings within the display. This however may lead to a noticeable pattern of (dark) pixels across the display. To avoid this, dynamic determination of said (blocks of) touch sensor pixels, by changing their position from one frame to another, will effectively prevent these pixels from being detected by the eye.

In a similar way the change in the stray capacitance between row lines and the counter electrode in an active matrix display (based on TFT-transistors as switching elements) can be used for detection of touching. This has the advantage that the stray capacitance between the row and the counter electrode is a fixed value, determined by the difference between the counter electrode voltage and the row (off) voltage and is not influenced by the pixel voltage.

Figure 4 shows an output 7'of a shiftregister 4, which is connected to a row select line 7 via a switch 13. The row select line 7 is also connected to a sensing circuit 14 which comprises a first input to a differential amplifier 15 having a resistor 16 between said input and its output. The other input is connected to ground in this example.

A change in C_{pixel} will generate a change in V_p and the output in V_x at node 17 can be expressed as:

$$V_x = -R_1 C_{pixel} \frac{dVp}{dt}$$

from C = Q/V, it follows,

$$\frac{dC}{dt} = -\frac{Q}{V^2}\frac{dV}{dt}$$

Hence, the expression for V_x can be written as

$$V_x = R_1 V_p \frac{dC_{pixel}}{dt}$$

which signal will increase when applying a force on the touch screen . If the output impedance of the row driver is high enough not to disturb this measurement switch 13 may be deleted. On the other hand, if necessary an extra switch18 may be used, which is only closed for measuring during non-selection of the row 7 (switch 13 may be opened then).

Since a detection circuit as shown in Figure 4 can be associated with any line (and /or column) continuous simultaneous touch detection of (blocks of) picture elements over the total display area is possible. This offers the possibility of the features in computer and telecommunication applications as mentioned in the introduction, like simultaneous detection of functions and selectively activating parts of a display screen.

In the example of Figure 5 the change in capacitance of a pixel (which may include a storage capacitance) is directly detected by measuring the oscillating frequency of the circuit, which is given by R x C_{pixel}. To determine if the screen has been touched, it is sufficient to measure a shift in the oscillating frequency of the circuit comprising a amplifier 15 and resistors R, R_1 (16, 16'). Said shift is determined at output 20 by means of a frequency measurement device 19, using for example a filter to detect an increase in frequency.

Figure 6 finally shows how the picture electrodes are incorporated in a typical microphone circuit. The pixel in its undisturbed state will have a voltage difference of (V_1-V_2) thereby having charges deposited on each side of the capacitor plate (the pixel). Perturbing the pixel by applying pressure will result in a change in its capacitance. This results in currents I_1 and I_2 flowing from both sides of the pixel electrode. The two said currents are equal in magnitude resulting into a similar voltage drop across the two R_1 resistors 16' in the circuit. As the two amplifiers 15 only measure the voltage change in R_1 due to the blocking capacitor 21 (C) , the circuit outputs 20 , 20' ideally provide the same voltage signal-that is,

$$\left[(V_1 - V_2)\frac{dC_{pixel}}{dt}\right]R_1\left[\frac{R_3}{R_2}\right].$$

Although the examples given so far have been related to liquid crystal display devices, in which the capacitive part of the impedance generally is influenced mainly by touch sensing, and mainly voltage measurement is described, similar reasoning applies to display devices, in which the resistive part of the impedance generally is influenced mainly by touch sensing, and detection methods based on current measurement are used.

So the protective scope of the invention is not limited to the embodiments described, while the invention is also applicable to other display devices, for example, (O) LED displays, electrophoretic displays, electrochromic displays, plasma displays, and other display devices based on e.g. field emission electrowetting etc.

Alternatively, flexible substrates (synthetic material) may be used (wearable displays, wearable electronics).

The invention resides in each and every novel characteristic feature and each and every combination of characteristic features. Reference numerals in the claims do not limit their protective scope. Use of the verb "to comprise" and its conjugations does not exclude the presence of elements other than those stated in the claims. Use of the article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

CLAIMS:

1. A touch sensitive display device comprising a multiple of picture elements and means for driving at least one of said picture elements together with means for monitoring the impedance of at least one of said picture elements and substantially simultaneously sensing a change in said impedance.

2 A touch sensitive display device as claimed in Claim 1 in which the means for sensing the change in said impedance measure a change in capacitance

3 A touch sensitive display device as claimed in Claim 1 in which the means for sensing the change in said impedance measure impedances of different groups of picture elements substantially simultaneously.

4. A touch sensitive display device as claimed in Claim 1 in which the means for sensing the change in said impedance measure a change in voltage.

5. A touch sensitive display device as claimed in Claim 1 in which the means for sensing the change in said impedance measure a change in current.

6. A touch sensitive display device as claimed in Claim 1 in which the means for sensing the change in said impedance measure a change in frequency.

7. A touch sensitive display device as claimed in Claim 1 in which the means for monitoring the impedance monitor at least one row of picture elements.

8. A touch sensitive display device as claimed in Claim 1 in which the means for monitoring the impedance monitor at least one column of picture elements.

9. A touch sensitive display device as claimed in Claim 1 in which the means for monitoring the impedance monitor a block of picture elements.

10. A touch sensitive display device as claimed in Claim 1 in which the means for monitoring the impedance comprise means for comparing the impedance of the picture elements with a reference value.

11. A touch sensitive display device as claimed in Claim 10 in which the picture elements comprise liquid crystal picture elements and the reference value is determined by impedance values of said liquid crystal picture elements having voltages outside the transition region of the liquid crystal picture elements.

12. A touch sensitive display device as claimed in Claim 10 in which the reference value is determined by impedance values of dummy liquid crystal picture elements.

13. A touch sensitive display device as claimed in Claim 10 in which the means for comparing the impedances comprise means to determine the reference value.

14. A touch sensitive display device as claimed in Claim 4 in which the means for measuring a change in voltage comprise at least one amplifier.

15. A touch sensitive display device as claimed in Claim 4 in which the means for measuring a change in voltage comprise a microphone detection circuit.

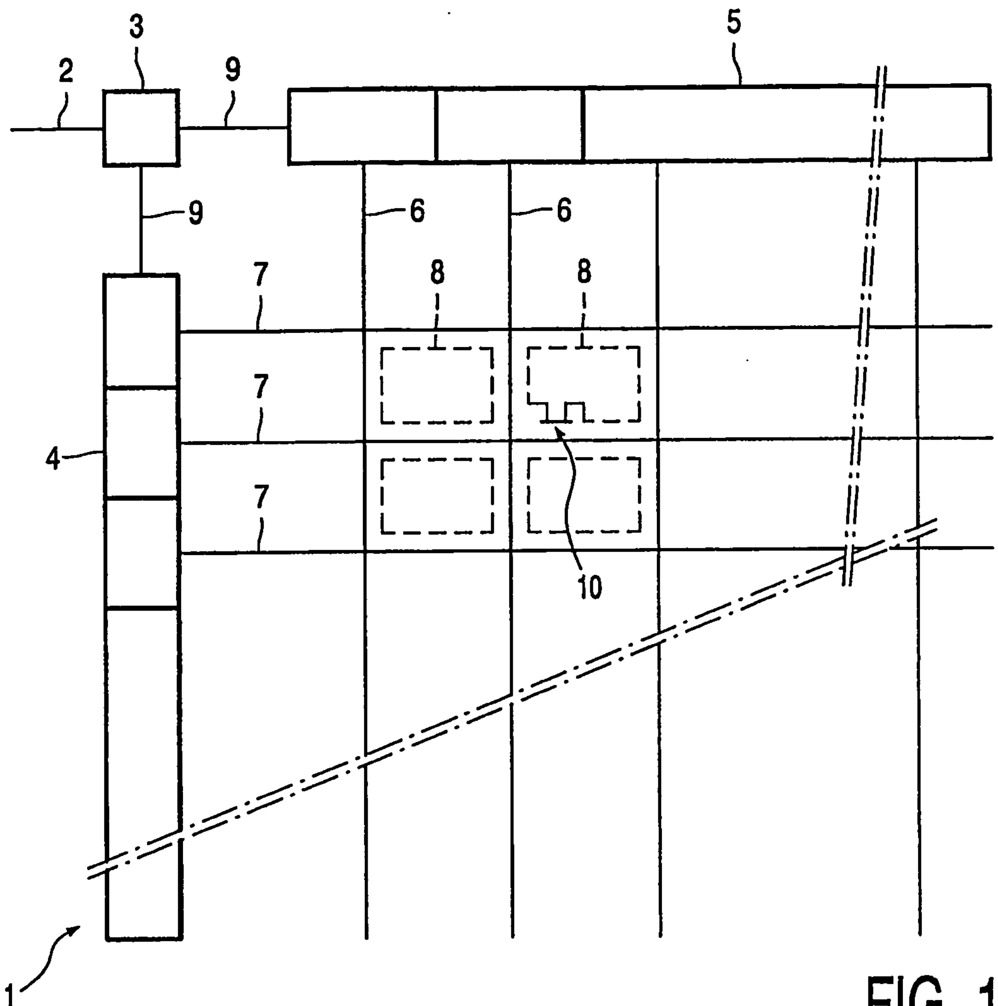

FIG. 1

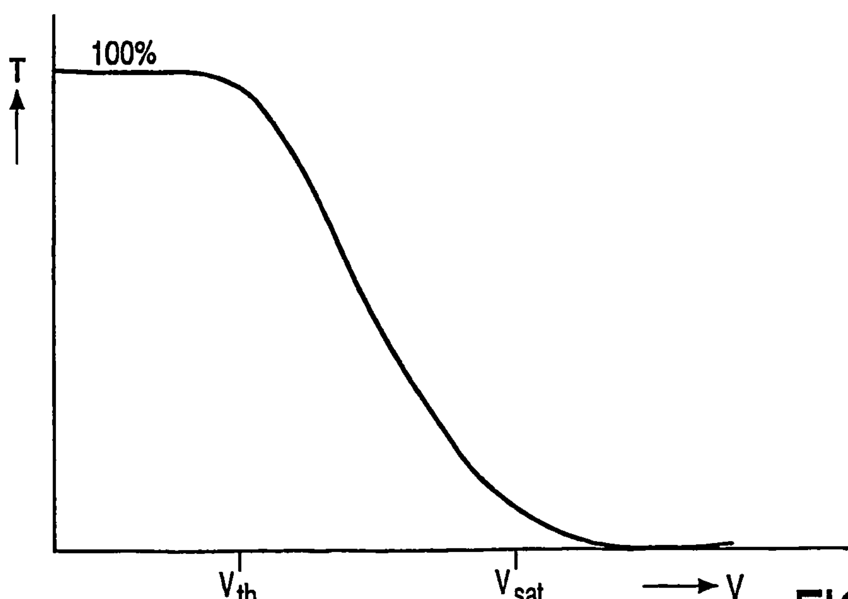

FIG. 2

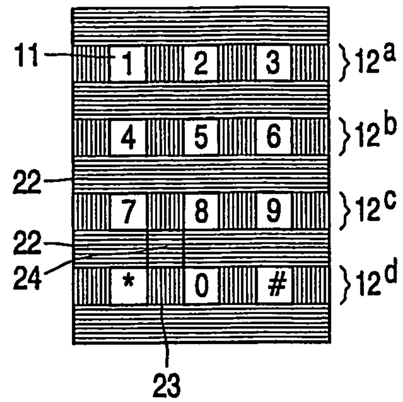
11
1
2
3
}12^a
4
5
6
}12^b
22
7
8
9
}12^c
22
24
*
0
#
}12^d
23

FIG. 3

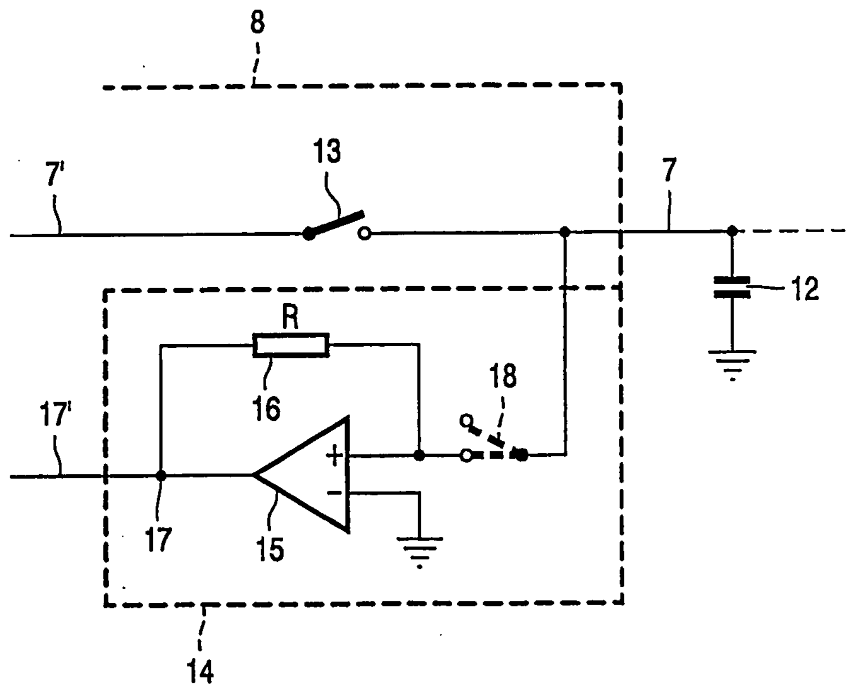
8
13
7'
7
12
R
16
18
17'
17
15
14

FIG. 4

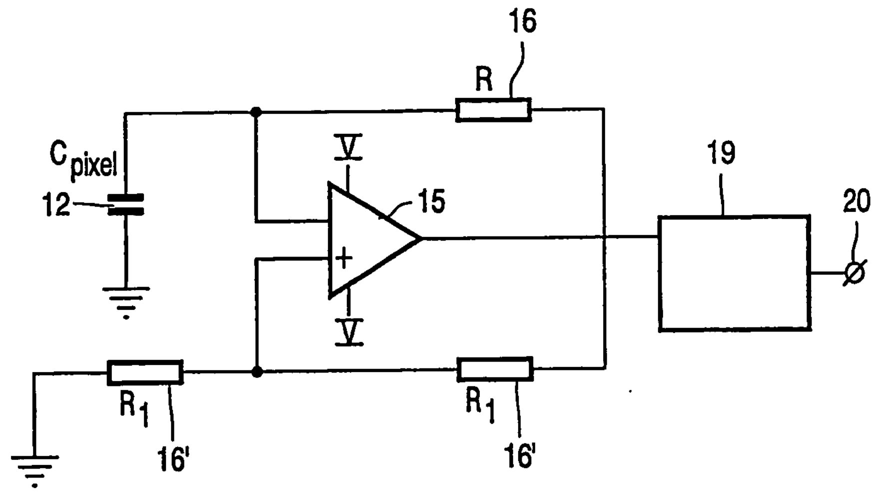
16
R
C_{pixel}
12
15
+
19
20
R_1
16'
R_1
16'

FIG. 5

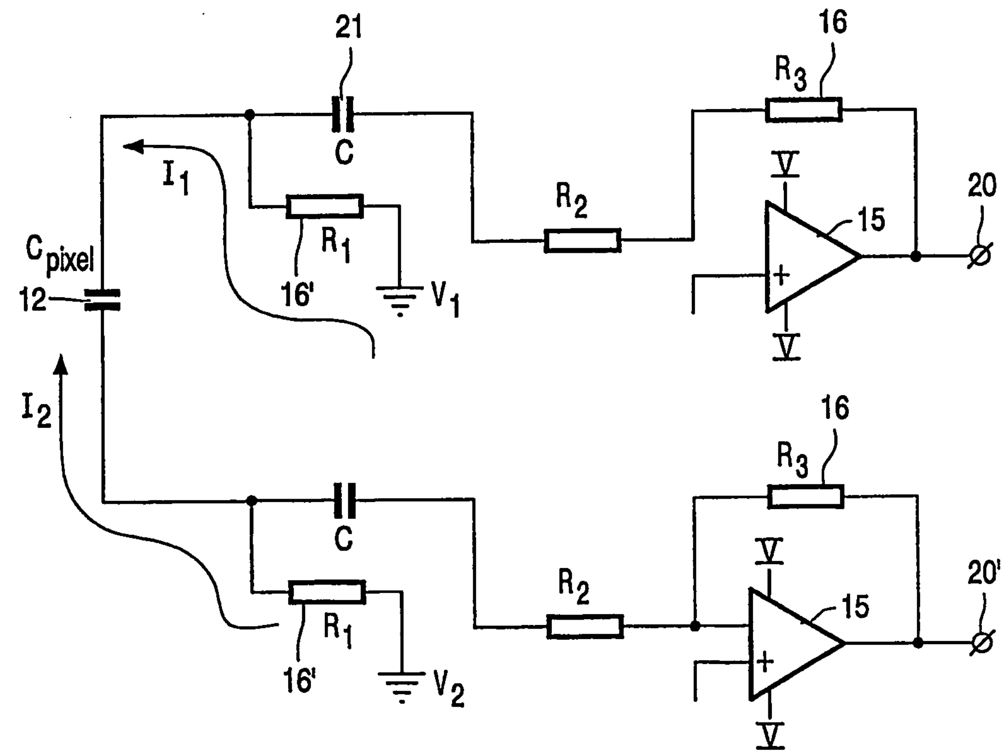
21
C
16
R_3
I_1
R_1
16'
V_1
R_2
15
+
20
C_{pixel}
12
I_2
16
R_3
C
R_1
16'
V_2
R_2
15
+
20'

FIG. 6

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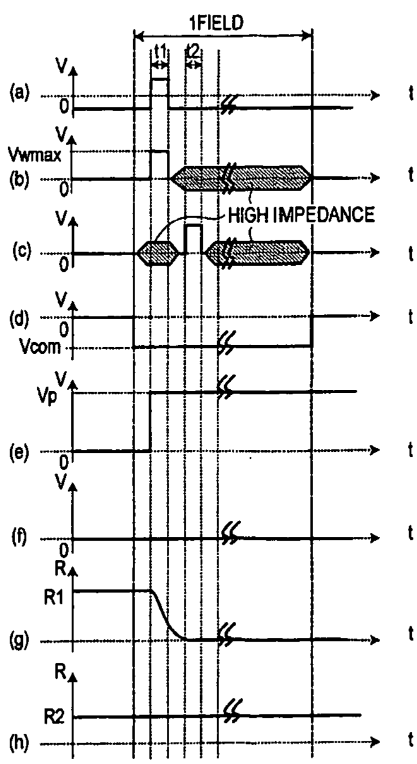
[Continued on next page]

(54) Title: DISPLAY APPARATUS WITH INPUT PEN FOR WEARABLE PC



(57) **Abstract:** An electrophoretic display apparatus or a ferroelectric liquid crystal display apparatus includes a display panel 10 including gate line electrodes 33 and source line electrodes 34 arranged in a matrix to provide a multiplicity of pixels at respective intersections of these electrodes, a gate line drive circuit 213 for driving the gate line electrodes 33, and a source line drive circuit 212 for driving the source line electrodes 34. When a display state of the display panel 10 is partially rewritten, a reference voltage of a common electrode 37 is switched to a negative voltage Vcom on the basis of 0 V which is a reference voltage at the time of multi-gradation level display. As a result, the display apparatus can be driven at a high voltage to permit high-speed rewriting of the display panel, so that a display response characteristic in writing of white/black binary data or black writing by pen input is improved.

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JC12 Rec'd PCT/PTC 19 OCT 2005

Application Data Sheet

Application Information

CD_ROM or CD-R?::	None
Number of CD disk::	0
Number of copies of CDs::	0
Number of copies of CRF::	0
Title::	DISPLAY APPARATUS
Attorney Docket Number::	00684.103077
Total Drawing Sheets::	6

Applicant Information

Primary Citizenship Country::	Japan
Status::	Full Capacity
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Status::	Full Capacity
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Correspondence Information

Correspondence Customer Number:: 5514

Representative Information

Representative Customer Number::	05514

Domestic Priority Information

Application::	Continuity Type::	Parent Application::	Parent Filing Date::
This Application	National stage of	PCT/JP2004/018433	12/03/2004

Foreign Priority Information

Country::	Application Number::	Filing Date::	Priority Claimed::
Japan	408273/2003	12/05/2003	Yes

Assignee Information

Assignee name::	CANON KABUSHIKI KAISHA
City of mailing Address::	Tokyo
Country of mailing address::	Japan

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

TOKO INTERNATIONAL PATENT OFFICE
Attn. Yamada, Ruyichi
Hasegawa Building 4F
7-7, Toranomon 3-chome
Minato-ku, Tokyo 105-0001
JAPAN

東京 APR 1, 2005 受領

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 31/03/2005
Applicant's or agent's file reference 10003077WO01	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/JP2004/018433	International filing date *(day/month/year)* 03/12/2004
Applicant CANON KABUSHIKI KAISHA	

1. [x] The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

   When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Fascimile No.: (41-22) 740.14.35

   For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   [ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

   [ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until **30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Jean-Michel De Caevel

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]: "Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]: "Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]: "Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or "Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]: "Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, Item 5 below.
10003077WO01		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/JP2004/018433	03/12/2004	05/12/2003

Applicant

CANON KABUSHIKI KAISHA

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 5 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
      [ ] The international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
   b. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. [ ] **Certain claims were found unsearchable** (See Box II).
3. [ ] **Unity of invention is lacking** (see Box III).
4. With regard to the **title**,
   [ ] the text is approved as submitted by the applicant.
   [X] the text has been established by this Authority to read as follows:
   DISPLAY APPARATUS WITH INPUT PEN FOR WEARABLE PC
5. With regard to the **abstract**,
   [ ] the text is approved as submitted by the applicant.
   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the **drawings**,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 1
      [X] as suggested by the applicant.
      [ ] as selected by this Authority, because the applicant failed to suggest a figure.
      [ ] as selected by this Authority, because this figure better characterizes the invention.
   b. [ ] none of the figures is to be published with the abstract.

Box No. IV Text of the abstract (Continuation of item 5 of the first sheet)

An electrophoretic display a pparatus or a ferroelectric liquid crystal display
apparatus includes a display panel 10 includingAn electrophoretic display appara
tus includes a display panel 10 including<An electrophoretic display apparatus i
ncludes a display panel 10 including<i> An electrophoretic display apparatus inc
ludes a display panel 10 including<i> <An electrophoretic display apparatus incl
udes a display panel 10 including<i> </i>gate line electrodes 33 and source line
electrodes 34 arranged in a matrix to provide a multiplicity of pixels at respe
ctive intersections of these electrodes, a gate line drive circuit 213 for drivi
ng the gate line electrodes 33, and a source line drive circuit 212 for driving
the source line electrodes 34. When a display state of the display panel 10 is p
artially rewritten, a reference voltage of a common electrode 37 is switched to
a negative voltage Vcom on the basis of 0 V which is a reference voltage at the
time of multi-gradation level display. As a result, the display apparatus can be
driven at a high voltage to permit high-speed rewriting of the display panel, s
o that a display response characteristic in writing of white/black binary data
r black writing by pen input is improved.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP2004/018433

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G09G3/34 G06F3/033 G09G3/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06F G09G G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 March 2005	31/03/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Morris, D

2

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0 601 837 A (SHARP KABUSHIKI KAISHA) 15 June 1994 (1994-06-15) column 9, line 49 - column 12, line 15; figure 1 column 14, line 6 - column 14, line 41; figure 3 column 16, line 11 - column 17, line 17; figure 5b column 20, line 12 - column 21, line 22; figures 5b,6 column 23, line 41 - column 24, line 44; figure 8 column 26, line 2 - column 29, line 6; figure 9 column 30, line 12 - column 31, line 21; figure 10 column 34, line 3 - column 35, line 32; figure 12 column 39, line 38 - column 40, line 56; figure 16	1-4,6,8 5,7,9
Y A	US 5 461 400 A (ISHII ET AL) 24 October 1995 (1995-10-24) column 11, line 54 - column 13, line 33; figures 1,7,9,10	5,9 1-4,8
Y	US 2003/011869 A1 (MATSUDA YOJIRO ET AL) 16 January 2003 (2003-01-16) paragraph ‘0091! - paragraph ‘0105!; figures 1-10 paragraph ‘0118! - paragraph ‘0162!; figures 3,4,12,13 paragraph ‘0170! - paragraph ‘0188!; figures 14,16-18	7
A	WO 03/079176 A (KONINKLIJKE PHILIPS ELECTRONICS N.V; JOHNSON, MARK, T; DESTURA, GALILE) 25 September 2003 (2003-09-25) page 5, line 18 - page 6, line 26; figures 1-6 page 9, line 28 - page 10, line 6	1,9

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/JP2004/018433

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 0601837	A	15-06-1994	JP	2774424	B2	09-07-1998
			JP	6175780	A	24-06-1994
			DE	69321811	D1	03-12-1998
			DE	69321811	T2	12-05-1999
			EP	0601837	A2	15-06-1994
			US	5430462	A	04-07-1995
US 5461400	A	24-10-1995	JP	2863363	B2	03-03-1999
			JP	5203927	A	13-08-1993
			DE	69315713	D1	29-01-1998
			DE	69315713	T2	18-06-1998
			EP	0552993	A1	28-07-1993
US 2003011869	A1	16-01-2003	JP	2003005225	A	08-01-2003
			JP	2003005229	A	08-01-2003
WO 03079176	A	25-09-2003	AU	2003206027	A1	29-09-2003
			EP	1488309	A2	22-12-2004
			WO	03079176	A2	25-09-2003

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/JP2004/018433	03.12.2004	05.12.2003

International Patent Classification (IPC) or both national classification and IPC
G09G3/34, G06F3/033, G09G3/36

Applicant
CANON KABUSHIKI KAISHA

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA"). However, this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of three months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:

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10/553625

JC12 Rec'd PCT/PTO 19 OCT 2005

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No. PCT/JP2004/018433

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This opinion has been established on the basis of a translation from the original language into the following language , which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ in written format

   ☐ in computer readable form

   c. time of filing/furnishing:

   ☐ contained in the international application as filed.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	2, 3, 5, 7, 9
	No:	Claims	1, 4, 6, 8
Inventive step (IS)	Yes:	Claims	
	No:	Claims	2, 3, 5, 7, 9
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following document/s/:
   - D1: EP-A-0 601 837 (SHARP KABUSHIKI KAISHA) 15 June 1994 (1994-06-15)
   - D2: US-A-5 461 400 (ISHII ET AL) 24 October 1995 (1995-10-24)
   - D3: US 2003/011869 A1 (MATSUDA YOJIRO ET AL) 16 January 2003 (2003-01-16)

2. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claims 1 and 9 is not new in the sense of Article 33(2) PCT.

2.1 The document D1 discloses (- cf. independent claim 1 of the present application) a display apparatus (- Fig. 1) comprising:

a display panel (- 1 - Fig. 1) including pixels arranged in a matrix;

pixel electrodes (- island electrode 23 - Fig. 2) provided to the pixels, respectively, and a common electrode (- common electrode Y - Figs. 1, 2) provided commonly to the pixels;

scanning lines (- common electrodes Y1-Yn - Fig. 1) and signal lines (- segment electrodes - X1-Xm - Fig. 1) for supplying a voltage to said pixel electrodes (- "a voltage approximately equal to the voltage across the segment electrode Xa and the common electrode Y1 (the voltage referred to as the "display voltage" hereinafter) is applied to the liquid crystals 21 in the area of the island electrode 23a." - col. 23, lines 49-54);

a drive circuit (- 2, 3, 6, 5 - Fig. 1) connected to said common electrode, said scanning lines, and said signal lines; and

a control circuit (- control circuit 13 - Fig. 1) for providing a signal to said drive circuit,

wherein said control circuit selectively switches (- "A control circuit 13 controls [image display mode, pen input mode]" - col. 11, lines 7-12)

a display drive mode (- "Image display mode" - col. 23, line 21) in which said

display apparatus displays an image on said display panel through sequential scanning of said scanning lines and application of a variable voltage (- "display voltage" - col. 23, line 52) to pixels via said signal lines by said drive circuit and

a rewriting drive mode (- "pen input mode" - col. 19, line 30) in which said display apparatus rewrites a part of pixels into black or white (- "turbid whitely" - col. 20, line 41, and "a part of image already written [..] can be erased." - col. 21, lines 7-10) through application of a voltage (- "not lower than Vth2" - col. 21, lines 11, 12), which is higher than a range of the variable voltage

(- i.e. the "display voltage" written to a pixel of D1 in the display mode comprises the sum of

- the variable image data voltage applied via the segment lines X, plus
- the voltage applied to the selected common line Y,

to achieve voltages "not lower the Vth1 and lower than Vth2" or "not lower the Vth2" [- i.e. see col. 23, lines 47-54 and col. 24, lines 21-28 of D1] wherein by definition, the voltage "which is not lower the Vth1 and lower than Vth2" and "not lower the Vth2" which is applied in the input pen mode [- i.e. see col. 20, lines 36-41 and col. 21, lines 7-13 of D1] must be greater than the range of the variable voltage applied to the segment electrodes),

to the part of pixels on a scanning line selected by said drive circuit.

Accordingly, the subject matter of independent claim 1 is not considered novel over D1 within the meaning of Article 33(2) PCT.

2.3 In addition (- cf. dependent claims 4, 6 and 8), D1 further discloses corresponding features of:

an external input device (- input pen 10 - Fig. 1);
a pen input device (- input pen 10 - Fig. 1); and
liquid crystal display apparatus (- "phase transition type liquid crystals" - col. 15, line 12).

Accordingly, the subject matter of dependent claims 4, 6 and 8 is also not considered novel over D1 within the meaning of Article 33(2) PCT.

3. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 7 does not involve an inventive step in the sense of Article 33(3) PCT.

3.1 In addition (- cf. independent claim 9 of the present application, and dependent claim 5), D2 which discloses corresponding features of:
a display panel (- Figs. 1, 2, 9);
pixel electrodes (- 12 - Figs. 3-5, 18 - Fig. 5);
common electrodes (- 19a, 19b - Fig. 5; Y1 - Y100 - Figs. 1, 9);
scanning lines (- y1 - y100 - Figs. 1, 9);
signal lines (- 13 - Fig. 4, 8; x1 - x128 - Figs. 1, 9); and
a drive circuit (- 94 - Fig. 10),
further discloses:
a position detection device (- 92 - Fig. 10; Rx1 - Rx128, Ry1- Ry100 - Fig. 9) for detecting a position designated by a positioning member (- 81 - Fig. 9) and outputting information on the detection position;
wherein when there is no output of said position detection device (- i.e. light pen location sensing unit 92 receives no input from the pen), said control circuit selects a display drive mode in which a gradation image is displayed on said display panel and said drive circuit applies a variable voltage to pixels through said scanning and data lines to display the gradation image on said display panel
(- insofar as D2 discloses the display in Fig. 9 is suitable for e.g. "an engineering workstation" [- col. 13, line 22] it is submitted that D2 implicitly discloses said display as employing a display drive mode), and
when there is an output of said position detection device (- i.e. "a signal sent from the display panel 91 in response to the light from the light pen" - col. 12, lines 55, 56), said control circuit selects a rewriting drive mode in which a part of pixels of said display panel is rewritten into black or white and said drive circuit scans a part of said scanning lines and applies a voltage [..], to a part of pixels to rewrite the part of the pixels corresponding to the position designated by the pointing member
(- " in response to the light from the light pen and a computer 93 recognizes a character, a figure, or a symbol based on the sensed data and displays the

recognized character or the like on the display panel 91 through the effect of a display control unit 94" - col. 12, lines 56-60).

As such therefor, the subject matter of independent claim 9 and dependent claim 5 is considered to comprise no more than the use of a technique, known from D2, of i.e.:

making notations on an active matrix tablet,

in an passive matrix display apparatus, known from D1, in which pixels have an analogous pen input (- see e.g. input pen 10 - Fig. 1 of D1).

Accordingly, in light of PCT Guidelines 13.14(a)(v), the subject matter of independent claim 9 and dependent claim 5 is not considered to involve an inventive step over a non-inventive combination of the teachings of D1 and D2 within the meaning of Article 33(3) PCT.

3.2 Furthermore (- cf. dependent claim 7), electrophoretic displays are known in the art, an example thereof being the electrophoretic display disclosed in D3 (- i.e. see e.g.).

As such therefor, the subject matter of dependent claim 7 is considered to comprise no more than the use of a technique, known from D1, of i.e.:

switching drive modes in a display in which pixels have a memory effect,

in an electrophoretic display apparatus, known from D2 at least, in which pixels have an analogous memory effect (- see e.g.).

Accordingly, in light of PCT Guidelines 13.14(a)(v), the subject matter of dependent claim 7 is not considered to involve an inventive step over a non-inventive combination of the teachings of D1 and D3 within the meaning of Article 33(3) PCT.

3.3 Dependent claims 2 and 3 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, see documents D1-D3 and the corresponding passages cited in the search report.